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RICE IN MALAYA.

By

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(*Concluded.*)

XI.—VARIETIES.

OVER 1,700 so-called varieties of padi have been collected in Malaya, judging by the vernacular names, but of these many differ only in name in different districts and in reality there are probably not more than 300—400 distinct varieties in the Peninsula.

An effort has already been made to classify Malayan rices and a considerable accumulation of data has been obtained, but the urgency of more important work has necessitated the postponement of the final classification to a future date, and experimental work has been concentrated on the leading varieties. Varieties of padi differ in shape, size, colour and hairiness of grain, in the length of the maturation period, in yield of grain per acre, in length of straw, in tillering power, in numerous vegetative characters, in culinary and milling qualities, in chemical composition and in other ways. Different local varieties of hard rice that is, those which have a vitreous fracture, can be grouped broadly into the following distinct classes according to the shape, and size of grain.

(*a*) Seraup type, which has a distinct shoulder on the anterior extremity of the grain.

(*b*) Radin type, which is very uniform in outline and of medium length.

(*c*) Siam type, which is always very long and frequently slightly curved.

(*d*) Rangoon type, which is markedly broad and thick in proportion to its medium length.

All the rices so far found in Malaya can be placed in one of these categories, but by far the most important classes are the Seraup and Radin types which probably include 80% of the total production.

(*a*) The Seraup type, which is most popular amongst the millers because of its weight and good milling qualities, is chiefly confined to the large flat coastal areas of Krian and Province Wellesley and to heavier clay soils around Kuala Kangsar and probably represents 25% of the annual crop.

It is commonly called a heavy ("berat") padi because of its high yielding ability and its long maturation period which averages 235 days, though strains can be bred to shorten or lengthen this period by 14 days. Strains of this variety in very fertile soil are capable of producing crops up to 850 gantangs of padi per acre in exceptionally good seasons and in first class land. Under average conditions the crop is rarely less than 500 gantangs per acre.

There are two chief sub-divisions of this type:

(1) "Seraup Besar" which has a long grain with a white tip.

(2) "Seraup Kechil" which is shorter and has a coloured tip.

"Seraup Besar" is known also as 'mayang,' 'mayang sakapol,' 'sakapol' etc.

(*b*) The Radin type is most popular because of its excellent culinary qualities and for this reason is common in all the smaller padi areas where the crop is grown for home consumption only, though it is also found in the larger areas in Kelantan, Kedah, Krian and other places. This padi is not very popular with millers because of its lightness compared with 'seraup' and because of the smaller size of grain. These factors have adverse effects on its milling qualities by raising the ratio of husk to kernel as compared with 'seraup.' Probably 50% of the annual crop is derived from this type which includes many sub-varieties of which the best known are "radin puteh," "radin merah," "radin kuning," "nachin," "riong," "lebat," "santap," "serendah." The variation in the maturation period of this class is very wide, its limits including 4 and 9 month varieties.

(*c*) The Siam type is rarely grown on a large scale but is quite common in small areas where it is chiefly cultivated on account of its large kernel and is used for food at special social functions. This type includes several varieties which are all probably descended from types introduced from Siam. They mature in 4 to 7 months.

(*d*) The Rangoon type: The bulk of the rice imported into Malaya annually comes from Rangoon and is characterised by its short, fat and thick shape. Doubtless locally grown rice of which the grain conforms to this type is descended from seed imported from Rangoon, but very little padi of this type is seen in cultivation in this country. Varieties of this type mature in from 4 to 6 months.

In contrast to the hard rices there are numerous varieties of glutinous rice ("pulut") characterised by their fracture which is never purely vitreous and by the fact that they boil to form a more or less gelatinous mass. They are of little economic import since

their consumption is limited to special ceremonial occasions and because as a diet they contain too much fat and are lacking in proteins. The most popular varieties are 'hitam,' 'galah,' 'kuching lekat,' 'labah,' 'chiakbong,' 'minyak,' 'kunpit' etc.

The method of studying varieties has been by means of pure lines. From the entire collection of varieties some 300, representing the most popular types in all the chief producing districts were grown as pure lines for five seasons.

For each season's sowing the seeds from a single plant only of each type were sown, the resulting seedlings being planted in rows of one hundred plants. Thus each type was represented by one hundred plants in each season, and records of botanical and agricultural characters were registered and checked each year.

Particularly promising types, from the point of view of yield, were multiplied and tested against selected 'seraup' and 'radin' strains, these tests still being in progess as all tests must cover at least three seasons so as to give an insight into average yielding ability under the seasonal variations which occur from year to year. Thus these tests raise the study of varieties from the level of a mere piece of academic research to a work of practical utility and at the same time furnish a check to observations made while the particular variety was grown in line culture.

Seasonal variations, with particular reference to rainfall, complicate the testing of varieties or strains considerably, for it is frequently found that a variety or strain under even slightly different climatic conditions on the same soil may give very diverse yields in two successive seasons.

Hence in testing work, it is necessary to strike averages over a period of several seasons in order to make sure that a given variety or strain is really more valuable than others and of course, the averages become the more reliable in proportion to the number of seasonal tests from which they are derived.

The following table shows the agricultural characters under Krian conditions, of some of the leading varieties in cultivation. Their botanical characters will be dealt with in a future paper on cassification. They are classed as "wet" padi in contrast to "dry" or "ladang" padi but several can be grown under either form of cultivation, for example, Sungkai, Bidor, several Radins, Gansar, Riong etc.

Variety.	Field No.	Type.	Maturation period (days.)	Average height (ins.)	Average tillering.	Average yield of grain per plant (4 years.)
Seraup kechil ...	52	Seraup	230	60	23	93
„ „ ...	36	„	235	48	21	94
„ , ...	186	„	246	63	21	81
„ besar ...	590	„	240	63	20	76
„ „ ...	15	„	233	65	21	85
Radin kuning ...	7	Radin	207	48	20	86

Variety.	Field No.	Type.	Maturation period (day.)	Average height (ins.)	Average tillering.	Average yield of grain per plant (4 year.)
Radin merah ...	4	„	194	45	19	76
„ puteh ...	13	„	200	48	20	80
Pahit ...	896	Seraup	212	60	20	86
Pahit ...	903	„	200	54	19	83
Machang ...	273	„	235	51	18	
Labah ...	668	Pulut	218	48	22	58
Hitam ...	697	„	234	42	25	67
Nachin puteh ...	642	Radin	217	48	24	59
Bujang melengong.	862	„				
Burong ...	779	„	200	48	12	50
Bunga machang ...	653	Seraup	167	45	15	41
Rangoon ...	649	Rangoon	140	30	12	40
Siam ...	667	Siam	180	48	20	72
Siam ...	820	„	184	48	24	73
	876	Ceylon	150	36	25	35
Gading kuning ...	630	Radin	185	48	22	91
Chantek ...	633	Seraup	180	60	23	95
Pontianak ...	634	Radin	182	48	21	90
Bidor ...	635	„	196	54	20	80
Selatan besar ...	636	„	220	54	16	75
Jintan tinggi ...	637	„	181	48	15	53
Manik ...	638	„	185	54	14	52
Seri layar ...	638	„	240	60	20	38
Rantai mas ...	640	„	163	48	21	56
Nachin ...	641	„	175	45	20	70
Negri ...	643	„	190	54	20	61
Bunga belimbing...	645	Seraup	190	60	17	60
Mayang bawang ...	646	„	225	63	21	50
Kedah ...	647	Radin	195	54	16	57
Bunga machang ...	652	Seraup	190	60	22	72
Serbok mas ...	659	Radin	172	51	15	63
Radin deli ...	666	„	219	48	16	67
Nias ...	689	„	184	42	12	48
Sungkai ...	690	„	186	33	8	35
Radin patani ...	691	„	182	39	16	51
Seri bumi ...	692	„	216	48	15	62
Jarom perak ...	710	„	190	54	18	65
Anak ikan ...	726	„	182	48	14	54
Antah beras ...	727	„	185	54	16	69
Rendah ...	875	„	151	30	28	60
Lebat ...	749	„	220	48	23	55
Tukal ...	789	„	184	48	18	58
Gansar ...	792	„	221	45	18	80
Bemban ...	821	Seraup	244	60	23	58
Riong ...	849	Radin	179	54	16	54
Punggong hitam ...	808	Seraup	243	60	15	47

XII.—CORRELATIONS.

A. Relationship between yield per plant and tillering power.

Although it has already been pointed out in section 4 that tillering varies enormously according to the fertility of the soil, yet under similar conditions, the variation fluctuates about the mean for each strain and each strain has its own inherent tillering ability. Thus the tillering powers of pure strains, 9, 52, 99, 36, 6, 247, were found to be 14, 18, 16, 20, 21, 22 respectively in season 1921-22. These figures are the averages of counts from 40 plants of each strain, all the strains being grown side by side in the same field under apparently similar conditions, care having been taken to avoid soil within 20 feet of the 'batas' (divisions between fields). In establishing a correlation between tillering power and yield of grain per plant, the object was to determine whether the tillering power of a plant could be used as an index of its yielding ability. For the conduct of the experiment twelve pure strains of the variety 'seraup kechil' were grown in rows of forty plants each, side by side, each plant occupying one-and-a-half square feet, this being found to be the optimum spacing in Krian. At harvest the mature ears of each plant were cut and bound in a bunch. When thoroughly dry the number of ears (fruiting tillers) in each bunch was recorded. Then each bunch of ears was hand threshed, and winnowed and the clean padi was weighed separately. Thus records of the number of tillers per plant and of the weight of grain per plant from 480 plants were compiled. From these records a mathematical calculation shown in table XII was made to determine any existing correlation between these characters. This calculation revealed a correlation coefficient of $.72 \pm .0186$ which indicates that there is a definite relation between these characters, so that strains having a high tillering power must be selected if increase in yield of grain is to be attained.

In actual experimental tests pure strain No. 9, for example, with an average tillering power of 14 had only an average yield per plant of 53 grammes, this strain having an average of 21 tillers in season 1921-22.

Naturally since seasonal variation has a direct effect on the tillering power of a variety or strain, comparisons between the tillering power of different strains can only be made during the same season and on the same block of land and preferably with as large a number of plants as possible. Thus in contrast to season 1921-22, the tillerings of the pure strains mentioned above were found to be respectively 17, 23, 19, 22, 24, 21 in season 1922-23.

TABLE XII. Correlation between Tillering and Weight of Grain per Plant.

Mean tillering = 19 : Mean weight = 78 Classes-tillering M = 19

Classes-Weight M = 78.

	5	8	11	14	17	20	23	26	29	32	35	fy	dy	fdy	fd^2y	E dx dy
157										2		2	79	158	12482	2054
142							1	5	8	2		16	64	1024	65536	9344
127						7	6	7	14	5	2	41	49	2009	98441	15533
112					4	11	31	17	6	1		70	34	2380	80920	10846
97				2	23	37	25	6	2			95	19	1805	34295	2717
82			1	10	32	39	19	1	1			103	4	412	1648	40
67			10	19	21	19	5	4				78	-11	-858	9438	1650
52		2	6	21	9	3	3	1				45	-26	-1170	30420	4446
37	3	1	9	8	1							22	-42	-902	36982	6847
22	1	4										5	-56	-280	15680	3248
7	2	1										3	-71	-216	15336	2769
fx	6	8	26	60	90	116	90	41	31	10	2	480		4362	401178	59494
														wy=4362	480	480
														480	=835.78	=123.737
														=9.08	w^2y= 82.45	less wx. wy
														w^2y=32.45	753.33	=7.082
															wy=$\sqrt{753.33}$	116.655
															=27.45	
dx	-14	-11	-8	-5	-2	1	4	7	10	13	16					
fdx	-84	-88	-208	-300	-180	116	360	287	310	130	32		375	wx $\frac{375}{480}$		
														=.7812		
														w^2x=.6099		
fd^2x	1176	968	1664	1500	360	116	1440	2009	3100	1690	512		$\frac{14535}{480}$=30.2812			
													less w^2x = .6099			
													29.6713			
													Dx 5.454			

$$R = \frac{116.655}{5.454 \times 27.45} = \frac{116.655}{149.60} = .779 \qquad E_r = +.67\frac{(1-R^2)}{\sqrt{N}} = +\frac{.67 \times .606841}{21.9} = .0186$$

$\therefore R = .78 \pm .0186.$

R = Coefficient of Correlation.

E_r = Probable error of R.

(B.) Spacing in Transplantation.

In Malaya wet padi is almost entirely sown in a nursery and later transplanted into the fields, most frequently with one transplantation only, but in very rich soils the seedlings are often transplanted twice, occasionally thrice and rarely four times. Transplantation of seedlings is undoubtedly beneficial, the advantages following this practice being a considerable saving of seed, a marked increase in yield and an improved quality. The chief disadvantages of transplantation are the necessity for a large supply of labour at one time, the necessity for opportune rains in the absence of irrigation, to enable the fields to be thoroughly prepared, and a decided lengthening of the maturation period of the crop. The physiological factors involved in transplantation are somewhat obscure but the conclusion at present, based on a number of experiments, is that transplantation acts in a similar way to root-pruning, the injury to the root system stimulating the growth of the sub-aerial portion and resulting in increased tillering. The root system of transplanted rice is developed from the lower nodes of the stem, the first or seedling root system dying completely in most cases. In very rich soil like that in Krian complete amputation of the original root system is the common practice. It was found that, in the best soils of Krian where three transplantations are the rule, that seedlings which had only been transplanted once gave a large vegetative growth but practically no grain. It was also found that if the original root system was not heavily pruned at the final transplantation, that the resulting plants were slow growing and eventually gave little grain. The origin of the custom of triple transplantation of seedlings in Krian cannot be traced, but the practice must have been evolved from many years of experience. Old men who have been planting rice in Krian for over forty years state that this practice has been in vogue as far back as they can remember. The practice affords a striking example for it shows that, where padi planting is concerned, most of the present day methods of cultivation attain a high degree of perfection from the point of view of the physiology of the rice plant and that the methods of the Malay planter are usually adopted with reason resulting from long experience.

The spacing of seedlings in final transplantation into the fields depends entirely on the nature of the soil, the thoroughness of cultivation and the average depth of water. In the richest parts of Krian or near the "batas" the optimum planting distance was found to be twenty by eighteen inches, this spacing producing a yield of over 600 gantangs (3,300 lbs.) of padi per acre. In the middle of the fields where there was no "batas" effect and in good soils the best distance was found to be seventeen by fifteen inches (3000 lbs. of padi per acre). In medium and soft soils, under average rainfall conditions, fifteen inches each way proved the best distance (2,500 lbs. of padi per acre). In hard medium soils one foot each way appeared to be the optimum distance under average conditions, but with more thorough cultivation the distance can be increased by 2 or 3 inches. In the better soils, it was found that close planting was always followed by severe damage by rats and that the optimum planting distances had to be reduced by nearly one fourth if the water was too deep (over eighteen inches) at the time of final transplantation.

These planting distances were determined by planting the same variety of padi ("seraup") on several one fortieth acre plots on the various types of soils mentioned. On each type of soil the padi was planted in duplicate plots at distances varying from ten inches square to twenty inches square and the yields of cleaned padi were recorded by volume and by weight. In most areas the Malays appear to have struck good average planting distances, though in Krian where the manurial effect of the "batas" are the most pronounced, they have hardly made sufficient allowance for it. Thus, under native planting conditions, it has been found that on the average an acre of padi cut so that none of it is more than twenty feet distant from a "batas" produces 1.7 times as much grain as an acre of padi cut so that none of it lies within twenty feet of a 'batas.' The high productive power of soil situated close to the 'batas,' is of course, entirely due to the richness of the soil in humus, which is derived from the decay of the vegetation used in constructing it. In areas where the soils are very hard the "batas" are made of stiff clay only and as such, produce little or no manurial effect on the padi growing near them.

C. The relation between the number of plants per hill and (*a*) tillering (*b*) yield.

It has already been indicated in section 4 that the tillering of padi plants, though an inherent character, is very considerably affected by environment. The chief environmental factors which affect the tillering power are the depth of water, the soil, the spacing of the padi plants and the number of plants per hill in final transplantation. With regard to the last mentioned factor an experiment was conducted in which several small plots were planted with the same variety of padi, ('Radin puteh') the hills being spaced at the optimum distance for the area (17 x 15 inches) but in each plot the number of seedlings planted per hill was varied to ascertain the effects on tillering and yield. The reslts are tabulated below:—

No. of Plants per hill	No. of tillers per hill (average of 100 hills)	Average Yield of padi per 100 hills	Average Yield per hill in grammes	Yield per acre in pounds
1	13.3	5,460	54.6	2,964
2	14.5	5,370	53.7	2,917
3	15.5	5,480	55.0	2,976
4	17.1	5,270	52.7	2,862
5	17.0	5,110	51.1	2,775

The experiment was conducted on first class land and the table shows that the tillering increases in proportion to the number of plants per hill up to four, though above this number the tendency is to decrease. At any rate as far as tillering is concerned, it makes little difference whether 1 or 4 plants are set to each hill.

The yield per hill and per acre show a definite tendency to decline when more than three plants are planted per hill. The Malays usually plant three to six seedlings per hill in transplantation

except in the best soils where the seedings become very robust before final planting and are easily handled so that the number used per hill is reduced to 2 or 3. In final planting the work must be done quickly hence the number of seedlings used really depends on the ease with which they can be handled, so that the number must vary according to soil conditions, for if the seedings are weak and thin, the planter cannot afford to waste time in singling out one seedlings at a time, when three or four can be picked up more quickly.

D. The Relation between the weight of padi grain and its value as seed.

Every grain on thirteen medium sized ears of padi, representing three well known varieties, was weighed and placed in a paper bag after its position on its parent ear was noted by a numbered diagram. In this way, over 2,000 grains were treated and sown in nursery boxes, each seedling being labelled and later transplanted to the padi fields. All seedlings were protected from rats by wire netting. At harvest the produce from each plant was weighed separately and the following table shows the results from two typical ears :—

GROUP Weight in Grms	Total no. of grains in group	Total no. of grains in group to germinate	Per cent. of total no. of grains	Average Weight of Crop per plant in grms.	
				Grain	Straw
Ear 4: variety 'Padi pahit.'					
.0000	1	0	0	0	...
.0125	13	0	0	0	...
.0150	11	3	27	47	...
.0175	2	1	50	47	...
.0200	6	4	67	52	...
.0225	12	7	58	43	...
.0250	29	21	72	49	...
.0275	75	48	64	46	....
.0300	38	26	68	44	...
.0325	10	6	6	42	...
Ear 12: variety 'Seraup'					
.020	7	7	85	75.7	347
.021	5	3	60	67.8	340
.022	8	5	62	56.0	317
.023	28	16	70	97.5	369
.024	35	25	72	78.2	383
.025	36	24	67	80.0	329
.026	20	13	65	96.3	395
.027	12	7	58	85.7	402
.028	3	2	67	80.3	415

The table shows that the very light grains are useless and should be avoided in selecting seed, and they usually are, since the Malaya generally immerse their seed in water so that light and empty grains float to the surface and are discarded. Once the light seeds are eliminated the remaining seeds show a like percentage of germination and apparently possess similar producing powers (allowing for experimental errors) as evidenced in column 5 of the table. The position which each grain occupied on its parent ear does not appear to have any effect on its value as seed. Theorizing from scientific principles this is the result that was expected for the essence of modern plant breeding demands that every seed of a pure strain should have the same germinal capacity regardless of size, provided that it is grown in a healthy and similar environment and has properly matured (mutations excepted).

XIII.—MANURES AND GREEN-MANURING.

Manures :—

Though little practised in Malaya, the application of manures as a means of increasing production is fairly widely known. The main reasons why manures are not universally employed are probably bound up with the lethargic disposition of the people, who prefer to eke out a bare subsistence with the expenditure of the minimum of energy rather than to apply themselves to the task of growing surplus rice for sale.

The rice cultivator is not ambitious, his wants are simple and easily supplied and he is accustomed to work but three months in the year, hence, since he finds that the old methods employed by his fathers are capable of gratifying his personal requirements, he is too conservative to launch out into new agricultural methods. Nevertheless, manuring is almost an established practice in several districts of Malaya though the method of applying it and amount applied are usually far from satisfactory, and certainly do not approach economic perfection. The manures which are known to be used by the cultivators include bone-meal, blood-meal, guano and green-manure in the from of grass and weeds. The first two mentioned are chiefly used in Malacca and parts of Negri Sembilan and are applied in various ways. Sometimes the nurseries only are manured, sometimes the nursery is manured and later the seedlings from the nursery are dipped into a thick manure paste before transplanting them into the fields. Frequently the nursery is unmanured, but the seedlings are plastered with manure paste and barely kept moist for 2 to 3 days or until their roots show through the paste, and then they are planted out in the fields. Commonly neither nursery nor seedlings are manured but the manure is run in with the water supply or broadcasted on the soil when fully prepared for planting. The amount of manure applied by this latter method is usually about 60 lbs. per acre and this amount is roughly approximated in manuring the seedlings also. Guano is in common use in Perlis, Kedah and parts of Perak but the guano used differs considerably in chemical and physical composition and also in price according to quality. The amount of phosphate in different samples of guano has been found to vary from 6.3% to 32%, but deficiency of lime in most samlpes renders the phosphoric acid "unavailable" to a large extent (1)

In Perlis and Kedah the Malays recognise three classes of guano classified according to colour as black, chocolate or light brown. Black guano is sold at $1.50 per bag, chocolate commands $0.75 per bag, and the poorer light brown stuff fetches $0.40 per bag, the bag containing roughly 25 "gantangs," or about 200 lbs.

The guano is broadcasted at the rate of three or four bags per acre every second year and the results are said to be good.

The Kedah phosphates contain more phosphoric acid than the Perlis samples as a rule, but aluminium and iron are so much in

excess of lime that the mass effect of the latter in rendering the phosphoric acid available is practically negligible. As nitrogen fertilizers these phosphates have a small value and in this respect the Kedah samples show superiority."

In studying the question of manures for rice soils, the problem must be approached from two aspects. In the first place it is necessary to know definitely the nature and amount of the constituents taken by the padi plant from the soil, secondly, the chemical and physical compositions of the soil must be determined by analysis.

The proportion of straw to grain and husk on good padi soils is roughly 5 : 4. The following table shows the average amounts in pounds of the chief constituents taken from the soil by a crop of 500 gantangs of padi per acre, as calculated from chemical analysis (2).

	Dry weight.	Nitrogen.	Potash.	Phosphate.
Straw ...	3,500	24.5	60	2.5
Padi ...	2,800	42.0	10	9.5

The straw amounting to about 3,500 lbs. per acre and equivalent to 24.5 lbs. of nitrogen 60 lbs. of potash and a small amount of phosphate is left on the land. The padi (grain and husk) removed annually from the land amounts to some 2,800 lbs. and contains 42 lbs. of nitrogen, 10 lbs. of potash and 9.5 lbs. of phosphate, so that theoretically these constituents should be returned to the land in the amounts indicated if the fertility is to be maintained. The growth of grasses which accumulates on the fields during the fallow period returns part, at least, of the required amount of nitrogen, as well as a certain amount of potash and a little phosphate, but the land is bound to deteriorate if the supply of any one of these necessary constituents becomes insufficient for the crop, although it has been shown is Section III, that local rice soils contain a supply of these constituents sufficient for at least twenty crops.

Once the land becomes deficient in any one of these three constituents the law of the minimum comes into force and the crop suffers in consequence. Heavy applications of nitrogenous matter have little or no beneficial effect on the grain crop, if the soil does not supply the minimum potash and phosphate requirements, nor is there any wisdom in applying heavy dressings of potash or phosphate if the soil is lacking in nitrogenous content. Thus, although our soils contain a stock of nutrient material sufficient for a long period, our fields have already been tilled for many years and the time is bound to come when the existing supply will be reduced below the minimum required for the rice crop. Even land which still produces good crops can benefit greatly by the application of manures, and the application of various manures to their land by Malays is an admission of the truth of this fact. The harder soils which must be ploughed before planting are most likely to show the beneficial effects of manures.

Manurial experiments were carried out at Lubok Merbau in the district of Kuala Kangsar, but owing to the curtailment of expenditure they were not continued long enough to render their results definitely reliable.

The experiments were designed to test effects of the simpler manures on the padi crop from the point of view of yield of grain.

Each manure was applied to two duplicate plots situated in different parts of the experimental area. At harvest each plot was divided into three or four sub-plots of one-fortieth of an acre each and the yield of each sub-plot was carefully measured.

The yields per acre were then calculated from the average of all the sub-plots under each manure. All the plots were similarly cultivated and were planted up with the same strain of padi ('Radin puteh' from the Krian Experiment Station). Moreover, all planting was done within one week so that climatic conditions should be similar in each case. The only factors which adversely affected the experiment were the unequal severity of rat attacks and the fact that a few plots were better situated as regards water supply than the others.

The land was first cleared of weeds and then ploughed. The application of manures immediately followed the ploughing and two to three weeks later the land was harrowed, irrigated and finally rolled.

The following table shows the average results of the two seasons over which the experiment was continued.

Manure.	Rate per acre.	No. of plots.	Average yield per plot.	Yield per acre.	Increase %
	cwts.		gantangs.	gantangs.	
Control ...	...	8	11	440	...
Cowdung ...	10	6	12¾	510	15.9
Basic slag ...	5	6	12½	500	13.6
Wood ashes ...	5	8	12	480	9.1
Nitrolim ...	2	6	12½	500	13.6
Super-phosphate	5	6	12¾	510	15.9
Sodium nitrate...	3	6	12½	500	13.6
Perlis guano ...	5	5	9¼	370	—16.
Potassium sulphate ...	3	5	14¾	590	34.
Ammonium sulphate ...	3	5	8½	340	—22.7
Fish guano ...	5	6	10¼	410	— 6.8
Lime ...	10	5	13	520	18.2
Oil cake ...	3	4	12¼	490	11.3

Cowdung, wood-ashes and Perlis guano were included in the experiment in view of their cheapness and the possibility of creating large supplies. Bonemeal, which is already fairly well known as a manure was omitted because, though orderod, it did not arrive with the other manures, and could not then be obtained in time.

Cowdung is well known as a good manure for padi throughout Malaya, but as cattle are scarce, so little is available that the cultivators hardly deem it worth while to put it on their land. The application of half a ton per acre produced an increase of 16% over the control plots. This amount of cowdung is, however, insufficient and it is considered that about four tons per acre would be required to give the best results.

Wood-ash proved fairly useful though disappointing in its result showing only an increase of 9% compared with the controls.

Perlis guano was a failure but this was due, partly at least, to the fact that one plot was very poorly supplied with water compared with the average and suffered badly accordingly, thus seriously reducing the average of all the sub-plots. One plot under lime and one plot under potassium sulphate were particularly favourably disposed with regard to water supply, and each carried a heavier fallow crop of grass than the average, but still the manures had an evident beneficial effect. One plot under ammonium sulphate and the adjacent one under fish-guano were covered with silt to a few inches as the result of a burst in the "tali ayer." This silt had a noticeable effect on the padi in the reduction of tillering and consequently showed diminished yields. Super-phosphate was the best of the remaining manures but the question of costs and the intrinsic values of the manures cannot be dealt with since prices have varied so enormously in the last five years. As mentioned above these experiments were intended to investigate the effects of simple manures and further experiments in this direction are being planned to start this year. In addition, however, combinations of various manures will now be tested. The merits of applying artificial manures to various green manure crops will also be studied since the writer is of opinion that there are great possibilities in this direction, provided that water supply can be fairly well controlled.

These experiments are useful in showing the fallacy of relying on trials which have only been continued over a short period. for under such conditions the effects of manures are masked by environmental factors, some of which are uncontrollable. The longer the trials of this nature are continued the more reliable do the results become, but in no case can definite conclusions be drawn until experiments have been continued for at least five years.

(1) Composition of Kedah and Perlis Phosphates—V. R. Greenstreet. Malayan Agricultural Journal. Vol. XI. No. 3, 1923.

(2 Some Rice Soils—M. Barrowcliff. Agricultural Bulletin F.M.S. Vol. I, No. 12, 1913.

Green Manuring.

Green manure is not conveyed to the padi fields, nor are green manure crops planted, but the thick growth of rank grasses and weeds, which springs up between the padi seasons is cut down and permitted to rot on the land for some weeks or is ploughed into the wet soil in the reparation of the land for planting. This practice is almost universal in Malaya. Moreover, in harvesting the crop in this country, it is customary to leave the straw on the land, only the ears being removed from the fields. In ploughing or trampling in this straw in the preparation of the land for the following season little of the organic matter produced in the crop is lost whereas if the hulls and straw are burned on the fields sixty-three per cent of the organic matter (about 21 lbs. of nitrogen) they contain is lost In the burning Therefore the practice of burning the straw after harvesting the crop. should be vigorously discourged. The only exception to this rule is the case of a field which has been very seriously damaged by insect or fungoid pests. It would not be economic to burn the straw on fields which had only been slightly infested with pests, indeed the writer has never known any insect or fungus attack to be sufficiently destructive to rice in Malaya to warrant the burning of the straw and grasses.

The incorporation into the soil of the rice straw and grasses grown on the land is beneficial to the following crop, but the amount of this green manure is rarely sufficient to give the best returns and the utility of importing additional vegetable matter to the land is usually reflected in the returns from the crop. The best method of applying green manure to rice land depends on whether the land is readily drainable and whether it contains an abundant supply of potash and phosphates.

In Malaya the heaviest producing lands are often found to be of a soft velvety consistency all the year round. Land of this nature usually produces a luxurious growth of rank grasses in the fallow season which when cut and permitted to rot on the fields forms an excellent green manure. Large areas of this type of land are found in Kedah, Province Wellesly and Krian and smaller patches occur here and there in the valleys in Rembau, Kuala Kangsar and Malacca.

The yields of rice obtained from these soils would indicate that a soft puddle was the most effective medium for producing fertility suitable to the needs of the rice plant. Such soils require no addition of nitrogenous manure though potash and phosphoric acid might be instrumental in producing heavier crops.

On most other types of land the fallow vegetation is more scanty and means for increasing the nitrogenous content of the soil are advisable. Green dressings of grass, leaves or other succulent vegetation can be placed on to the land prior to or during the preparation of the soil for the rice crop or if such material is not available a green manure crop can be grown on the land itself and later incorporated with it.

As the water supply is not controlled in most padi areas and as our rainy seasons are not very well defined, the sowing of green manure crops is attended with varying results. It may happen that the land is still flooded at the time when green manure seeds should be sown, or shortly after the seed has germinated the young plants may be killed by inundation due to heavy rains, or again the seedlings may be parched by excessive drought and thus produce little vegetation. The best time to sow green manure seeds is about three or four weeks before the padi crop is harvested when under normal conditions the water is being drained off the land. The land is then of a thick muddy consistency and supplies ideal conditions for the rapid germination of the seeds which should be broadcasted thickly and evenly. Thus the seedlings get a good start before the land becomes hard and dry and they afford shade, after the padi is removed, which tends to keep the soil cool and to retain moisture near the surface to the further advantage of the plants.

As ordinarily understood the term "green manure" is limited to the use of leguminous plants because of the well known power which their roots possess of enriching the soil in this respect, though modern work seems to indicate that the power of roots to fix atmospheric nitrogen is not limited to plants of the natural order "*Leguminosae*." Used in a broad sense, however, the term includes any quick growing plant which can be grown to yield a supply of foliage suitable for incorporating with the soil to augment its nitrogen content. Grass, for example, when cut and turned into the soil forms an excellent green manure if applied in sufficient quantity especially in the presence of moisture.

The following are the most promising leguminous green manures grown at the Krian Experiment Station :—

(1) *Sesbania aculeata*—A legume which grows rapidly and withstands varying conditions. This plant, broadcasted thickly in the padi fields a month before harvest yielded a mass of vegetation eight feet in height in five months and once it became well established it was found to endure flooding of the land for several weeks without any apparent detriment. It seeded well in the padi fields, but as the land in this district is usually fallowed for about 4½ months only it is advisable to keep a small plot growing elsewhere for seed purposes.

(2) *Cajanus indicus*—This plant will not tolerate standing water. It can be broadcasted thinly (5 lbs. to the acre) as with Sesbania or dibbled in hills spaced two feet apart each way. It forms a thick cover and sheds leaves abundantly thus adding a considerable amount of organic matter to the soil. The fallow season in the rice fields is not long enough to permit of seeding and the crop should be cut and incorporated with the soil after about three or four months growth before the stems become woody.

(3) *Tephrosia purpurea* like Cajanus will not stand submergence but grows fairly easily on wet soil. It should be thinly broadcasted

or can be dibbled into hills spaced two feet apart each way. It should be ploughed into the land when it is about two and a half feet high, that is after about three months growth.

(4) *Crotalaria juncea* grows quickly and produces a thick cover. It may be broadcasted fairly thickly and cut after three months growth before flowering and ploughed into the soil. It does not stand inundation for long.

(5) *Phaseolus mungo* (green) is difficult to establish on padi fields in its early stages but once established it thrives fairly well forming a useful green manure which should be ploughed after three months growth. In broadcasting about 10 lbs. of seed are required per acre.

(6) *Phaseolus mungo* var *radiatus* (black) is more difficult to establish than its green variety but produces more foliage and takes longer to flower and seed.

(7) *Canavalia eniformis* produces a heavy cover in three months but is difficult to establish in the heavy Krian soils.

(8) *Vigna catjang* grows rapidly forming a dense cover. The seed should be dibbled into hills about one foot apart in rows spaced about two feet apart. From the point of view of green manuring, the trailing variety is preferable and should be ploughed in just before flowering.

(9) *Centrosema Plumierii* is very difficult to establish on padi land unless conditions are exceptionally favourable and will not tolerate standing water. Surface cultivation assists the growth considerably and under good conditions a thick cover is formed.

The following table shows the average results of two seasons' trials with green matter added to the land in addition to that supplied by the natural growth during the fallow season.

	Manure.	Rate per acre.	No. of plots.	Yield of padi per acre.	Increase.
A	Control ...	...	4	410	...
B	Grass ...	10 cwt.	4	460	12%
C	Grass and Lime ...	10 cwt. & 5 cwt.	4	510	24%

In the above experiment, with regard to C. one of the plots was greatly favoured in its water supply, but still, it was evident that the lime increased the effect of the green material considerably.

Though results show which crops can be grown in the padi fields, experiments have not yet been carried far enough to show definite conclusions. There is however, no doubt as to the beneficial effect of green manures more especially in conjunction with artificial fertilizers.

It is found that if phosphates and potash are applied to green manure crops, the latter are more quickly established and form thicker covers, and field experiments are now being put in operation to test the value of this combination as measured in increased yields of grain.

XIV.—CATCH CROPS.

Intensive cultivation of the soil is not practised in Malaya except by Chinese market gardeners who laboriously work up all classes of soil rendering them very fertile and profitable. These gardens only cover a very small total area and are always situated near to the large towns where Chinese control the prices of vegetables and thus ensure to themselves sound returns.

There is room for considerable development of the padi fields of Malaya by the cultivation of catch crops during the fallow season, but it is doubtful if the cultivators, long accustomed to 3 months work in the year, will ever exert themselves to profit by such culture. Increase of population would appear to be the only force which is likely to arouse our cultivators from their inherent antipathy to strenuous effort and drive them to put their land to better use during the non-padi season. One crop of rice, a few coconut trees and unfailing sources of fish in rivers and rice fields together with easy earnings on rubber estates to cover the costs of luxuries such as tobacco and the average cultivator lives happily. Under these easy conditions of existence intensive cultivation of the soil is likely to remain confined to our Chinese market gardeners.

The following crops have given good results as catch crops at the Krian Experiment Station :—

(*a*) (*Ipomaea batatas*) Sweet Potato Malay ; Ubi Kledek.

In 1917, immediately after harvest half an acre of padi land was dug up, ridged and planted with this crop. This plot yielded 6,500 lbs of tubers or at the rate of 5.8 tons per acre. Dry weather prevailed throughout the entire growing period with the result that a high percentage of small undeveloped tubers was produced ; moreover the ridges were spaced six feet apart, whereas this distance might easily have been reduced to 4½ or 5 feet. No weeding was done.

	$—cts.
Chankolling and ridging ½ acre	13.65
Land rent (½ acre 5 months)	4.00
Cost of cuttings 1600 @ 10cts per 100 ...	1.60
Planting 4 coolies @ .40cts	1.60
Lifting and bagging ½ acre	6.00
Cartage to market 2 carts @ $1.50 each ...	3.00
Total cost of production ...	29.85
Sale of crop 48.45 pikuls (6,500 lbs) @ $1.00 per pikul	48.45
Profit per half acre ... = ...	18.60

Thus, though larger tubers would have fetched $1.50 or $1.75 per pikul, the crop, grown under very dry conditions, gave a handsome return, in fact a better return than would have been earned by planting padi.

(*b*) (*Arachis hypogaea*) Ground nuts Malay ; Kachang goring.

Planted on ridges one feet high and 3 feet apart this crop yielded at the rate of 12 pikuls of nuts per acre. This yield might have been materially increased had the plants been spaced one and a half feet apart on both sides of the ridges instead of one foot apart on the top of the ridges only ; moreover, weeding costs would then have been reduced.

	$—cts.
Chankolling and ridging ½ acre	13.65
Land rent ½ acre 5 months	4.00
Cost of seed 20 katis @ 10cts per kati ...	2.00
Sowing 2 men @ .40cts each	—.80
Weeding 4 men „ „	1.60
Lifting and bagging the crop	6.00
Cartage to market 1 cart, 3 miles	1.50
Total cost of production ...	29.55
Sale of crop 6 pikuls @ $7/- per pikul ...	42.00
Profit per half acre	$12.45

(*c*) (*Ricinus communis*) Castor Oil Malay ; Jarak.

This crop was grown successfully on the 'batas' of rice fields, when seed was dibbled in to a depth of 2-3 inches at intervals of four feet and lightly covered. No other cultivation was required. The seed was sown during the padi harvest in March and the crop was mature in August, yielding at the rate of 4 katis of seed per chain of batas. The seed was found to contain 30% of oil, employing the rough native methods of extraction, therefore the yield of oil per chain of 'batas' is approximately 1.5 katis (33 fluid ounces). Two coolies can hole and one cooly can easily expel the oil from 40 katis seed in a day.

	$—cts.
Cost of seeds, 1 gantang @ .40cts	—.40
Holing and sowing per 10 chains of batas 2 coolies @ .40cts each	—.80
Harvesting 1 coolie 5 hours @ 10ct per hour ...	—.50
Oil extraction 40 katis seeds 1 coolie @ .40cts ...	—.40
Total cost of production ...	$2.10cts.
Sale of oil from 10 chains of batas = 33 × 10 ozs = 2 gallons (approx) @ $2.40 per gallon (40cts per bottle)	4.80
Therefore profit per 10 chains batas	$2.70

Of course, castor is a crop which, if cultivated on a large scale, would soon swamp the market, but as the plant will only grow on the "batas" of the rice fields, the area could never assume very large proportions.

Moreover, the crop could only be grown on the 'batas' in the areas where the rice soils are soft since castor will not thrive in the heavy clay of which the 'batas' are composed in the areas where the rice soils are hard, and more than half the rice lands in Malaya belong to the latter category. In a district like Krian it might be profitable to establish small oil mills and a refinery if the Malays could be induced to sow this crop on a large scale and to prepare oil for export, or at least to supply the local demand, which is a large one. The labour involved in sowing and harvesting the crop is practically 'nil' and the clearing of weeds from the batas periodically would tend to reduce rat trouble, for rats breed prolifically in the batas during the non-padi season, so that castor would appear to be a good crop to grow wherever the batas are formed of soft decaying vegetation as in the Krian District.

Zea mays (Maize) Jagong.

Maize is perhaps the commonest crop grown by Malays on the batas in the North of the Peninsula. It is grown sometimes concurrently with padi sometimes as an intercrop, the more frequent practice being to sow it some 2 or 3 months before harvest. Seed is dibbled into holes spaced about one foot apart on the 'batas' and no cultivation is given to the crop which is rarely left to mature since it is mostly consumed in the green state as a vegetable. A portion of the crop is matured for the market or for seed purposes. The cost of cultivating and harvesting this crop is negligible and good yields are easily obtainable except in years of heavy rainfall which results in the submergence of the 'batas.'

Coleus parviflorus Ubi Kemeli.

This plant is grown on ridges in the padi fields for its tubers which form a good food and are readily saleable. The methods and cost of cultivation are the same as in the case of sweet potatoes. It is grown chiefly in Province Wellesley and commands prices similar to those obtained for sweet potatoes but is usually sold by the "gantang" as the tubers are fairly small (up to about three inches in diameter) and thus readily measured. Small parcels of this crop are sold at twenty cents per gantang. The yields obtainable from this crop depend entirely on the soil, the amount of cultivation and the weather conditions, all factors which affect the size of the tubers, very considerably.

Sagittaria sagittifolia Keladi Ayer.

This plant is grown in the rice field for its tubers in districts where Chinese predominate as it forms a good pig food. It is planted in much the same way as rice (transplanted) and under similar conditions of irrigation and is usually restricted to those rice fields which rarely or never dry in the non-padi season. It is most commonly seen in Province Wellesley but is found occasionally in Kedah, Krian and Malacca. The tubers are sometimes sold at two dollars per pikul (133 lbs) but are generally stored by the cultivator and fed to his pigs. The tubers are eaten by the Chinese to a small extent when other food is scarce.

Nicotiana Tabacum (Tobacco.)

Tobacco also grows readily on the rich soil of the "batas" in Krian and parts of Kedah, but like the castor-oil plant will not do well on the heavy clay "batas" found in most of the padi areas in Malaya. The tobacco plants spaced at intervals of three feet along the "batas" which are cleared of weeds, shoot up very quickly provided that light showery weather is experienced, and leaves become large and rank. The number of leaves is reduced to about fifteen by topping the plants when they are about two months old so that only large leaves are produced. The only cultivation necessary is occasional ring weeding around each plant and it is advisable to examine the plants for caterpillar pests periodically. Grown in this manner one chain of 'batas' produces at least half a pound of dry leaf with the expenditure of very little energy and yet few Malays take the trouble to ensure a cheap supply of tobacco for their own use or for sale to their neighbours or to local cigar factories.

Coix lacryma jobi (Job's Tears,) Menjelai.

This crop is occasionally grown on the 'batas' in Krian and Province Wellesley in the same way as maize. It is more commonly found in Pahang and Kelantan where it is grown sometimes, as an intercrop but is more often grown broadcasted with padi under "ladang" or "huma" cultivation.—Two types of "menjelai" are grown. A hard shelled type which is crushed and fed to poultry, etc. and a soft shelled form which is eaten. The grain is roasted to facilitate husking and boiled like rice or ground into flour for baking. The plant grows excellently on the 'batas' in Krian and matures rapidly giving a good crop. The only objection to this crop as a useful addition to Malayan cereals is that it ripens unevenly, though it might be possible to breed out a type which would overcome this defect.

Various other crops which are regularly grown in a very small way on the batas include several types of beans, (kachang) cucumbers (timun) lady's fingers (terong) etc.

The success of catch crops, or intercrops, depends on several factors of which the following are the most important: they must mature in less than five months; they must grow easily and they must command a ready sale.

The crops above mentioned which can be grown in the rice fields either between the padi seasons, or concurrently with rice on the 'batas,' do not include all possible crops, but merely serve to show the scope of productiveness which is at present scarcely fringed.

The crops which can be grown in the non-padi season, would, moreover, tend to reduce the cost of padi production because their cultivation would leave the rice fields in a cleaner condition and thus reduce the cost of preparing the land for padi. In addition, the general effect of the extra tillage required in growing crops between padi seasons would be beneficial to the soil and hence tend to increase padi yields.

Custom, the inbred habits of the cultivators, and the ease of existence are all contributary causes leading to the general neglect of these sources of wealth and food production.

This state of affairs can only be altered by increase of population or by external forces tending to curtail our imports of rice. As our population is increasing slowly but surely, a time may come when the true value of subsidiary crops may be appreciated.

XV.—EXPERIMENTAL ERROR.

In comparing the yielding capacities of different pure strains or of different varieties of padi, it is necessary to adopt a standard range for errors in calculations which is generally known as the experimental error.

Not only in field work but in dealing with any scientific problem the first essential consideration is accuracy, whether in details of description of characters or measurements of volume, length, weight, etc., and the precision of accuracy attained is the most important factor in adjudging results. No measurements can be made with such a degree of accuracy that they can be regarded as absolutely correct, because there are always several independent sources of error to be considered.

Generally, errors can be divided into two groups. (1) Those which can be eliminated. These include errors in instruments such as a faulty measuring rod and a badly adjusted balance. Obviously these errors can be remedied by substituting good instruments for the poor ones or by compensation. To this group also belong personal errors, for instance the varying depths to which different coolies will tap a rubber tree, and mistakes in reading scales, computing calculations, and counting weights, which are common errors. (2) The second group of errors comprises those which are indeterminate in their nature and cannot be entirely eliminated, no matter how much care is taken in an experiment. The occurrence, even in small areas, of pockets of soil of varying physical and chemical composition may be taken as an example of this type of error.

It is this second group of errors with which the scientist is chiefly concerned for the errors included in the first group may be largely reduced by practice or by compensation.

Three methods are employed in determining the relative accuracy of measurements (a) The mean error, (b) the average deviation, (c) the probable error. Of these methods the mean error, (which is the square root of the arithmetical mean of the square of the errors) is seldom used in scientific work.

The average deviation (which is the sum of the deviations divided by the number of deviates) is the easiest to determine, but the "probable error" method is the most accurate and consequently the most popular.

The term "probable error" is rather misleading but its meaning may be made clear by defining it as a number placed after a result with a plus and minus sign between; and it indicates that it is an even wager that the true result lies between limits so indicated. The "probable error" is ascertained by submitting a number of results to the mathematical formula P.E. $= .67 \sqrt{Ed^2 \div n-1}$ in which "d" is the

deviation from the mean and "n" is the number of results investigated. This formula is based on probabilities and was originally invented for and applied to astronomical calculations. In Season 1921-22 this formula was applied to 90 pure strains of padi of the variety 'Seraup Kechil,' in order to ascertain the experimental error in comparing pure strains under Krian Experimental Station conditions, in connection with pure line selection for increased yield of grain. Each pure strain was planted in triplicate in plots of one hundred plants each, each plot of the same strain being planted in a different part of the field. At harvest the weight of dry clean unhulled grain from each plot was carefully recorded and the weights are tabulated in table XIII. An examination of these results indicates that in most cases the yields of the triplicate plots are uniform. It is not possible to treat the yields of 370 plots of one hundred plants each directly by the method of least square for the evaluation of the "Probable Error" since the strains which produced the various lots of triplicate plots are inherently different. A comparison of strains 1, 20 and 36 discloses this fact. It is probable that environment influence, such as the occurrence of rich pockets of soil, etc. contribute partially to the difference in yield of the different plots of each strain, but the large differences between the different strains are probably due to the different constitutions of the various strains of padi. It becomes necessary therefore to treat each set of results from the several strains in such a way as to bring them to a common basis of comparison so that finally they may be examined graphically and combined into one computation by the method of least squares. This can be done by assigning percentage values to each result, the percentage values being calculated on the mean yields of the plots of each individual strain. This has been done in table XIII. The primary object of this experiment was the detection of the measure of accuracy attainable in using small plots since in manipulating large numbers of pure strains the work becomes more amenable to supervision (within limits) the smaller the area under the crop. The application of the above mentioned formula to the figures contained in table XIII results in a calculated "Probable Error" of $\pm$ 10.7% which indicates that no significance can be attached to any result which does not show an increase or decrease of more than this amount when compared with any other result. The harvest, during which the figures used in the calculation of this probable error were compiled, was an exceptionally bad one. Heavy rains caused the padi to lodge in the fields which were flooded to a depth of 9 to 16 inches during the entire harvesting period.

Thus, much grain was lost before and in the process of cutting the crop, in transporting the grain from the fields, in threshing and later through germination of the grain which could not be dried quickly. In a normal harvest, plots of a size similar to those which were used in the experiment only gave a "probable error" of $\pm$ 3%.

The difference between this figure and $\pm$ 10.7% adequately portrays the havoc wrought by rains during the harvest.

In all pure line testing an experimental error of 10% which is considered a safe margin on which to base calculations, is assumed, except when a wet harvest occurs when it is raised to 12%.

The application of this experimental error is of extreme importance in the comparison of the yielding abilities of a large number of different pure strains in enabling selections to be made with the minimum of cost, from small plots.

It must be understood that the calculated "probable error" can only be applied to the land on which the experient was conducted or to land in the same neighbourhood where soil and cultural conditions are approximately the same. The same crop may, under varying conditions of soil, water supply, and cultivation, show a different "probable error" so that a result obtained, say in Krian cannot be safely applied to a crop grown in Malacca though it is unlikely to vary considerably from it.

For this reason, it is desirable that experimental stations in each typical area should standardise their soils by ascertaining the "probable error" of cultivation before making variety comparisons, testing different forms of cultivation of the relative merits of various manures.

The following experiment may be mentioned as an example to show how precautions were taken to reduce experimental error in weighing lots of padi in pure line selection work. When padi is harvested it contains a considerable quantity of moisture and it was necessary to determine what period, under average weather conditions, must elapse before the weighings should be taken until each sample had reached that condition. Five bags of padi of the same variety, each containing one gantang of grain, were weighed separately immediately after winnowing and at frequent intervals afterwards covering a period of thirty seven days. The weights of each lot in the following table :—

WEIGHTS IN GRAMMES OF FIVE BAGS OF PADI EACH CONTAINING ONE GANTANG

Harvested 7.4.21. Variety Seraup Kechil.

Dates of Weighing.	A.	B.	C.	D.	E.
8.4.21 ...	2,737	2,770	2,770	2,732	2,719
11.4.21 ...	2,606	2,661	2,662	2,628	2,662
12.4.21 ...	2,591	2,614	2,647	2,614	2,592
13.4.21 ...	2,542	2,586	2,596	2,556	2,539
14.4.21 ...	2,527	2,567	2,582	2,542	2.522
15.4.21 ...	2,512	2,547	2,560	2,522	2,498
16.4.21 ...	2,502	2,542	2.552	2,512	2,492
18.4.21 ...	2,502	2,542	2,542	2,507	2,491
19.4.21 ...	2,499	2,537	2,537	2,506	2,482
20.4.21 ...	2,494	2,532	2,532	2,502	2,477
21.4.21 ...	2,479	2,514	2,517	2,472	2,472
22.4.21 ...	2,469	2,502	2,489	2,457	2,445
23.4.21 ...	2,459	2,492	2,482	2,445	2,442
25.4.21 ...	2,459	2,484	2,479	2,444	2,434
26.4.21 ...	2,456	2,480	2,470	2,441	2,429
2.5.21 ...	2,472	2,497	2,497	2,462	2,452

Harvested 7.4.21. Variety Seraup Kechil

Date of Weight.	A.	B.	C.	D.	E.
3.5.21 ...	2,467	2,492	2,472	2,462	2,452
4.5.21 ...	2,468	2,502	2,502	2,467	2,447
5.5.21 ...	2,477	2,507	2,507	2,472	2,457
6.5.21 ...	2,477	2,510	2,510	2,472	2,461
14.5.21 ...	2,497	2,522	2,522	2,497	2,472
15.5.21 ...	2,497	2,522	2,522	2,492	2,472
30.5.21 ...	2,480	2,490	2,520	2,480	2,450
29.8.21 ...	2,479	2,495	2,517	2,478	2,452

The above figures indicate that the padi loses weight with fairly uniform rapidity up to the fourteenth day. Up to that period the padi showed an average loss in weight of 8.9%, the variation in weight after that period being dependent on weather conditions.

A final weight, taken 144 days after that first recorded proved this statement.

TABLE XIII.

Pure line No.	Plot No.	Wt. of Grain in Grammes	Mean.	% Mean.	D.	D^2.	$\leqslant D^2$.
1	1	6,000	5,670	106	6	36	
	2	6,000		105	6	36	216
	3	5,000		88	12	144	
6	1	7,100	7,360	96	4	16	
	2	7,000		95	5	25	122
	3	8,000		109	9	81	
8	1	6,100	6,130	99	1	1	
	2	6,600		108	8	64	114
	3	5,700		93	7	49	
9	1	6,200	5,430	114	14	196	
	2	5,400		99	1	1	366
	3	4,700		87	13	169	
10	1	5,900	5,630	104	4	16	
	2	6,300		112	12	144	416
	3	4,700		84	16	256	
12	1	6,400	6,030	106	6	36	
	2	6,900		114	14	196	632
	3	4,800		80	20	400	
19	1	6,300	5,920	106	6	36	
	2	6,500		110	10	100	392
	3	5,000		84	16	256	
20	1	4,200	4,350	99	1	1	
	2	4,700		114	14	121	222
	3	3,840		90	10	100	
21	1	4,910	4,170	109	9	81	
	2	4,590		104	4	16	266
	3	3,920		87	13	169	
22	1	3,900	4,310	91	9	81	
	2	4,830		112	12	144	234
	3	4,200		97	3	9	
29	1	4,500	4,110	109	9	81	
	2	5,220		109	9	81	186
	3	2,620		82	18	324	

Pure line No.	Plot No.	Wt. of Grain in Grammes	Mean.	% Mean.	D.	D^2.	ΣD^2.
36	1	5,800	5,000	116	16	256	
	2	4,650		93	7	49	386
	3	4,550		91	9	1	
41	1	5,600	5,080	110	10	100	
	2	4,560		89	11	121	222
	3	5,090		101	1	1	
47	1	5,860	5,660	103	3	9	
	2	6,390		112	12	144	378
	3	4,720		85	15	225	
48	1	6,860	6,920	99	1	1	
	2	7,130		103	3	9	14
	3	6,760		98	2	4	
52	1	5,623	5,630	100	0	0	
	2	5,820		103	3	9	18
	3	5,450		97	3	9	
61	1	5,800	6,030	96	4	16	
	2	6,970		116	16	256	416
	3	5,320		88	12	144	
66	1	6,140	5,750	106	6	36	
	2	6,450		112	12	144	504
	3	4,670		82	18	324	
68	1	5,570	5,820	96	4	16	
	2	6,920		118	18	324	536
	3	5,980		86	14	196	
70	1	5,800	5,630	103	3	9	
	2	6,000		106	6	36	126
	3	5,080		91	9	81	
71	1	5,480	4,919	111	11	121	
	2	4,203		87	13	169	294
	3	5,040		102	2	4	
72	1	5,420	5,080	106	6	36	
	2	5,150		101	1	1	86
	3	4,720		93	7	49	
88	1	5,700	5,640	101	1	1	
	2	5,550		98	2	4	6
	3	5,690		101	1	1	
99	1	5,180	5,330	98	2	4	
	2	5,540		104	4	16	24
	3	5,270		98	2	4	

Pure line No.	Plot No.	Wt. of Grain in Grammes	Mean.	% Mean.	D.	D^2.	ΣD^2.
172	1	4,780	5,260	90	10	100	
	2	5,880		111	11	121	222
	3	5,120		99	1	1	
186	1	5,770	5,910	97	3	9	
	2	5,930		100	0	0	18
	3	6,040		103	3	9	
192	1	6,090	6,200	98	2	4	
	2	6,680		108	8	64	104
	3	5,830		94	6	36	
203	1	6,260	5,730	109	9	81	
	2	6,180		108	8	64	434
	3	4,770		83	17	289	
208	1	5,060	5,000	101	1	1	
	2	5,370		107	7	49	114
	3	4,560		92	8	64	
211	1	5,140	4,920	104	4	16	
	2	5,230		107	7	49	186
	3	4,380		89	11	121	
218	1	5,530	5,020	110	10	100	
	2	5,520		110	10	100	600
	3	4,000		80	20	400	
232	1	5,540	5,190	107	7	49	
	2	5,610		108	8	64	338
	3	4,430		85	15	225	
238	1	5,230	5,060	103	3	9	
	2	5,570		110	10	100	278
	3	4,370		87	13	169	
247	1	5,910	5,410	109	9	81	
	2	5,850		108	8	64	434
	3	4,480		83	17	289	
254	1	5,120	5,500	93	7	49	
	2	6,620		120	20	400	618
	3	4,750		87	13	169	
257	1	5,870	5,880	100	0	0	
	2	6,440		109	9	81	162
	3	5,340		91	9	81	
262	1	5,570	5,320	105	5	25	
	2	5,600		105	5	25	150
	3	4,810		90	10	100	

Pure line No.	Plot No.	Wt. of Grain in Grammes	Mean.	% Mean.	D.	D^2.	ΣD^2.
105	1	5,550	5,470	101	1	1	
	2	5,740		105	5	25	62
	3	5,120		94	6	36	
112	1	4,690	5,090	92	8	64	
	2	5,530		109	9	81	146
	3	5,050		99	1	1	
113	1	4,700	5,080	93	7	49	
	2	5,400		106	6	36	86
	3	5,140		101	1	1	
111	1	4,050	4,620	88	12	144	
	2	5,370		116	16	256	416
	3	4,450		96	4	16	
119	1	5,250	5,050	104	4	16	
	2	5,140		102	2	4	56
	3	4,720		94	6	36	
123	1	4,970	5,010	99	1	1	
	2	5,170		103	3	9	14
	3	4,900		98	2	4	
140	1	5,800	6,400	91	9	81	
	2	6,330		99	1	1	182
	3	7,080		110	10	100	
150	1	5,460	4,780	114	14	196	
	2	4,520		95	5	25	302
	3	4,350		91	9	81	
151	1	5,490	6,010	91	9	81	
	2	5,690		95	5	25	302
	3	6,850		114	14	196	
161	1	4,490	4,690	96	4	16	
	2	5,260		112	12	144	224
	3	4,310		92	8	64	
167	1	5,450	5,620	97	3	9	
	2	5,690		101	1	1	14
	3	5,720		102	2	4	
169	1	4,840	5,330	91	9	81	
	2	5,720		107	7	49	134
	3	5,440		102	2	4	
170	1	4,100	4,810	85	15	225	
	2	5,260		109	9	81	342
	3	5,080		106	6	36	

Pure line No.	Plot No.	Wt. of Grain in Grammes	Mean.	% Mean.	D.	D².	≒D².
263	1	5,820	5,790	100	0	0	
	2	6,300		109	9	81	162
	3	5,250		91	9	81	
280	1	5,440	4,730	115	15	225	
	2	4,400		93	7	49	338
	3	4,340		92	8	64	
284	1	6,190	6,230	99	1	1	
	2	6,870		110	10	100	182
	3	5,620		91	9	81	
290	1	5,400	4,990	108	8	64	
	2	4,620		93	7	49	114
	5	4,950		99	1	1	
291	1	4,950	4,880	102	2	4	
	2	5,360		110	10	100	248
	3	4,330		88	12	144	
293	1	4,900	4,810	102	2	4	
	2	4,770		99	1	1	6
	3	4,750		99	1	1	
319	1	4,830	4,900	98	2	2	
	2	5,290		108	8	64	102
	3	4,580		94	6	36	
333	1	5,070	4,510	112	12	144	
	2	4,900		109	9	81	666
	3	3,563		79	21	441	
342	1	5,030	5,180	97	3	9	
	2	5,420		105	5	25	38
	3	5,083		98	2	4	
343	1	5,400	5,440	99	1	1	
	2	5,880		108	8	64	114
	3	5,050		93	7	49	
362	1	5,600	5,750	97	3	9	
	2	5,870		102	2	4	14
	3	5,780		101	1	1	
371	1	6,420	6,240	103	3	9	
	2	6,050		96	4	16	26
	3	6,250		101	1	1	
373	1	5,150	4,980	103	3	9	
	2	4,970		100	0	0	18
	3	4,830		97	3	9	

Pure line No.	Plot No.	Wt. of Grain in Grammes	Mean.	% Mean.	D.	D^2.	ΣD^2.
524	1	4,990	4,500	111	11	121	
	2	4,420		98	2	4	206
	3	4,090		91	9	81	
528	1	5,600	4,900	114	14	169	
	2	4,510		92	8	64	296
	3	4,590		94	6	36	
564	1	5,820	5,390	108	8	64	
	2	5,650		105	5	25	258
	3	4,690		87	13	169	
568	1	5,689	4,930	115	15	225	
	2	3,970		81	19	361	602
	3	5,140		104	4	16	
570	1	5,890	5,360	110	10	100	
	2	6,000		112	12	144	728
	3	4,200		78	22	484	
582	1	4,200	4,270	98	2	4	
	2	4,530		106	6	36	56
	3	4,090		96	4	16	
588	1	5,770	5,080	113	13	169	
	2	4,970		98	2	4	294
	3	4,490		89	11	121	
589	1	5,300	4,840	109	9	81	
	2	4,690		97	3	9	126
	3	4,540		94	6	36	
594	1	5,100	4,770	107	7	49	
	2	4,420		93	7	49	98
	3	4,780		100	0	0	
602	1	5,320	4,850	110	10	100	
	2	4,390		90	10	100	200
	3	4,840		100	0	0	
603	1	4,760	4,270	111	11	121	
	2	4,100		96	4	16	186
	3	3,960		93	7	49	
615	1	4,510	4,410	102	2	4	
	2	4,480		102	2	4	24
	3	4,220		96	4	16	
620	1	4,600	4,450	103	3	9	
	2	4,450		101	1	1	26
	3	4,290		96	4	16	

Pure line No.	Plot No.	Wt. of Grain in Grammes	Mean.	% Mean.	D.	D^2.	ΣD^2.
376	1	5,410	4,880	111	11	121	
	2	5,570		114	14	196	942
	3	3,660		75	25	625	
377	1	6,360	5,260	121	21	441	
	2	4,750		90	10	100	662
	3	4,680		89	11	121	
378	1	3,810	4,510	85	15	225	
	2	5,060		112	12	144	378
	3	4,650		103	3	9	
402	1	5,430	5,360	101	1	1	
	2	5,120		96	4	16	26
	3	5,520		103	3	9	
405	1	5,540	5,660	98	2	4	
	2	5,540		98	2	4	24
	3	5,890		104	4	16	
114	1	5,740	5,330	108	8	64	
	2	5,130		96	4	16	96
	3	5,120		96	4	16	
417	1	5,200	4,770	109	9	81	
	2	4,640		97	3	9	106
	3	4,470		96	4	16	
446	1	5,580	5,030	111	11	121	
	2	5,020		100	0	0	242
	3	4,480		89	11	121	
458	1	5,680	4,730	120	20	400	
	2	3,660		78	22	484	888
	3	4,840		102	2	4	
492	1	5,400	5,270	102	2	4	
	2	5,870		111	11	121	294
	3	4,530		87	13	169	
509	1	6,570	6,320	104	4	16	
	2	6,900		109	9	81	266
	3	5,480		87	13	169	
517	1	6,030	5,110	118	18	324	
	2	5,140		101	1	1	686
	3	4,160		81	19	361	
522	1	4,800	5,050	95	5	25	
	2	5,780		115	15	225	350
	3	4,560		90	10	100	

Pure line No.	Plot No.	Wt. of Grain in Grammes	Mean.	% Mean.	D.	D^2.	$\leqslant D^2$.
629	1	4,300	4,320	100	0	0	
	2	4,680		108	8	64	128
	8	3,970		92	8	64	

$\leqslant d^2 = 22630$ N = 90 Total = 22,630

$$\text{P. E.} = \pm .67 \sqrt{\frac{22630}{89}}$$

$$= \pm .67 \sqrt{254.37}$$

$$= \pm .67 \times 15.95$$

$$= \pm 10.6865$$

$$= \pm 10.7\%$$

XVI.—IMPROVEMENT OF THE RICE CROP.

The idea of improving cereal crops seems to have originated during the first decade of the last century, though it was not until the last decade of the same century that any real progress was made. Improvement of grain crops can be effected in five ways (1).

(1) Amelioration of environment.
(2) Importation of seed.
(3) Mutation.
(4) Hybridization.
(5) Pure line selection of seed.

(1) *Amelioration of environment:* All cereal crops respond readily to improved methods of tillage or to any improved condition of the soil such as would be derived by the addition of manure. The fact that crops will grow at all depends on the law of the minimum, which demands that certain minimum amounts of nutrient substances shall be contained in the soil. For each crop there is an optimum condition of amelioration; for too luxurious conditions tend to develop vegetative growth at the expense of yield of grain, which is almost always the main object in growing cereals, but as far as local crops are concerned, there is little fear of over-cultivating the soil.

Improvement in the methods of water-control is the first concern in 'wet' padi cultivation. Following satisfactory water-control, additional tillage and the growth of green dressing plants with subsequent ploughing in of the organic matter would appear to offer most promise with the rice crop in this country from the view point of improving the texture of the soil as well as of increasing the proportion of nutritive material.

(2) *Importation of seed:* It sometimes happens that the variety of a cereal used in a district is found to yield unsatisfactorily and that seed imported from some other district or country, where environmental conditions are somewhat similar, shows a distinct improvement. This has been proved with rice in the Federated Malay States, for selected Krian seed has been grown with marked success in several districts and in some cases, it certainly threatens to supersede the varieties cultivated previously. Importations may frequently show no immediate signs of success but, since all plants possess to some extent an inherent power of adapting themselves to their environment, they may in time become acclimatized and then prove better than the local types. Thus, a Japanese variety of rice which took seven years to become acclimatized to conditions in Italy now supersedes all other varieties on 250,000 acres in that country.

However, improvement of already acclimatized types is usually the better method to adopt, because no matter how much any kind of cereal seed is improved under one particular set of conditions, it may fail under even slightly different environmental conditions, to produce good crops, even after years of acclimatization.

(5) *Pure line selection* :—Pure line selection is by far the most important method of crop improvement and has developed along two lines, the one which may be said to have begun with the English breeder le Couteur, though this breeder was perhaps unaware of the extreme importance of his method, which may be described as that of "individual plant selection"; and the other known as "mass selection" being developed by several European breeders at about the same time. The latter method largely led up to the doctrine of evolution as propounded by Darwin, whose theory was that new species could be created by continued selection of individual variations. Later, de Vries' work on the nature of variation disclosed the imperfections in the scientific basis of this theory, so that it became less important; and the former method started by le Couteur and independently discovered by Nilsson and elaborated in detail by the work of Johansson, Hays and others now holds the field.

Colonel le Couteur, a wheat breeder of Jersey, was visited about 1810 by la Gasca of Madrid who pointed out that his wheat cultures, though appearing of general uniformity, were of mixed nature and really consisted of a number of distinct sorts growing together. Le Couteur saved seed separately from individuals of the different sorts and tested the progeny of each. He found that the offspring bred pure to the type of the parent, each to each, and almost by instinct he did not seek to improve them further.

Similarly Sheriff, working on similar lines isolated the rare and exceptional plants in his cultures and sowing their seed separately, compared their progenies. He became eminently successful in isolating, multiplying and distributing heavy yielding types of wheats and oats. Though in his original experiments he took only the very exceptional plants for his cultures (and these were not easily discovered), he subsequently followed le Couteur's method of selecting a large number of types showing small differences and deciding on their utility by a comparison of their progenies.

This method has stood the test of time and the strong competition of the continental school, who considered that the English breeders were resting content with what nature had provided them, not availing themselves of the possibilities of continuous selection in the actual production of types theoretically conceived. The almost complete failure of the continental school and the complete vindication of the methods of the early English breeders form an extremely important chapter in the history of plant breeding.

The pure line method was independently discovered by Nilsson in 1892. Working at Svalof in Sweden he found that the number of failures that had to be recorded in the attempt at the production of types of preconceived forms by the process of continuous selection was enormous, but in that year he stated "I had occasion to observe here and there novel autumn wheats which at once opened interesting perspectives to me; they represented only 5 per cent of the whole collection. They showed uniformity and characteristic type such as we had never previously found in our plantings." These proved to be the productions of seed saved separately from individual plants.

(3) *Mutation :* In his study of this subject, de Vries (2) showed that, as is now generally accepted by biologists, variations are of two kinds, (a) fluctuating variations, which are due entirely to environmental influence and are not heritable and (b) discontinuous variations which arise unexpectedly and are due to sudden and unexplainable changes in the germinal substance of an organism. These latter variations which are of infrequent occurrence, but are always transmittable, are called mutations. Mutations are not due to any recognisable stimulus, nor can they be controlled. They appear fortuitously, and if they show any particularly desirable characters they have only to be maintained and developed as pure lines, in order to make that desirable character permanent.

Nevertheless, simple as this method of finding new races may seem, it is not favoured by breeders because, on the average, mutations do not appear to be of a progressive nature, indeed the records (3) of the chief cereal breeding station in Europe now seem to indicate that all mutations are retrogressive and that only characters formerly in existence arise in this manner, probably as the result of previous natural crossing in remote generations. If this is correct, it is of little importance to spend time in seeking for things which can be produced artificially and with much greater assurance of obtaining an advance.

(4) *Hybridization :*—Hybrid plants result from cross-fertilization between different strains of the same variety, or between different varieties. The laws which govern hybridization were first investigated by a monk named Mendel in 1865 although the value of his work was only appreciated in 1900, when the study of the problems which it solved became known as "Mendelism."

If a plant is regarded as being built up of a number of factors, each of which behaves as a separate and individual unit and each of which is transmitted as a unit from parent to offspring, then it is easy to understand that a hybrid is a new combination of the factors existing inherently in the parents which produced it. Thus a hybrid may differ from either or both of its parents in morphological or physiological characters, or in both respects, but it is almost always possible to reproduce the parental types of a hybrid by self-fertilizing it and then separating out the progeny systematically.

The hybridization method of improving cereals is important when it is required to combine in one strain, two or more desirable characters such as heavy yield and early maturity. Preliminary work on these lines is already in progress with rice in Malaya.

To be successful hybridization must follow pure line selection so that the practical values of the crossed varieties may be fully known. Crosses should always be made with a definite purpose in view, care being taken to avoid crossing sorts which are too dissimilar in character or are impure. After artificial crossing, pure line selection must be applied rigidly again in order to pick out the different types which have segregated out and to purify them prior to testing them on a commercial scale.

Since that discovery a colossal amount of experimentation has been executed and the results have been subjected to the most critical scientific analysis and from them the following points, which direct the methods of modern plant breeding, emerge.

Ordinary varieties of plants are built of many elementary forms. These forms may be distinguished by botanical or agricultural differences, or they may be of such a nature as to present neither of these distinguishing features, their differences being of a physiological nature ultimately distinguishable by chemical analysis. They have to be selected once, and then if the original selection is not of hybrid nature their constancy is assured as long as contamination is provided against.

Thus modern plant-breeding is rather of the nature of the isolation of the elementary species already present than of the creation of new species.

This method of plant improvement has been applied to rice in the Krian district of Perak where there is a continuous area of some 56,000 acres of irrigated rice land of which roughly 52,500 acres are planted annually with wet-rice. This being one of the largest and most important rice-producing areas in Malaya, the attention of the Department of Agriculture was turned early towards it as being the most promising for experimental work so that the main rice-breeding station was established at Titi Serong, some three miles from Parit Buntar, the administrative headquarters of the district.

This district produces annually an average of fourteen million gantangs of clean unhusked rice (padi) so that every 10% increase in production would mean over one and a quarter million gantangs of unhusked rice or sufficient to feed over ten thousand persons for a year.

An examination of the standing crop in this district showed clearly that each of the chief varieties of wet-rice was made up of a number of types differing in height, in robustness, in tillering power, in yielding capacity, in size of grain, in length of ear etc. A normal crop of a specified variety will yield on the average a certain weight of rice, but from such a crop it is possible, by selecting individual plants or preferably single ears, and by growing their progeny separately, to isolate a number of types or strains, each of which bears a distinctive character or characters. Some of these characters will be physiological, that is, will be indicated by the nature of the response to environment. If such as isolation of strains is effected and the grain of each strain is multiplied separately until there is enough to sow one acre of each, the yields of each will not equal the average for variety. Some will give more and some will give less than the average in such a manner that the sum of all the yields divided by their total number will equal the average for the variety. Clearly a direct and immediate increase of yield will be the result of such a selection if in future years, only the highest yielding strains are used for seed purposes; but it is also evident that the wider the selection of strains the more likelihood there is of obtaining the high results desired.

During the harvest of 1915-16, 300 strains of padi were selected from the heaviest producing areas in Krian and grown as pure lines. At the following harvest 1,000 more selections were added to these, making a total of 1,300 strains. In the first year a single ear of each of these strains was sown in the nursery and all the resulting seedlings were planted in a line varying in length according to the number of seedlings derived from each parent ear. In transplanting the seedlings into the fields only one plant was set to each hill, and a space of four feet was maintained between each strain (line). In each succeeding season the grain from a single plant only of each strain was used for seed thus ensuring the purity of the strains, while any strains which proved to be of hybrid nature were immediately eliminated.

All these strains were planted out as pure lines, in triplicate, for two successive seasons, before any elimination of the poorer ones could be made, owing to bad weather conditions and the great influenza epidemic which affected the cultivation of the crop very adversely in 1918. In each season since that date, approximately half the number of strains under trial has been discarded, so that in the season 1922-23 only 77 strains, representing five varieties were under trial. The following table shows the frequencies and the weights per plant in grammes as recorded during the last four seasons.

Weight per plant in grammes.	Frequencies.				Column 1 continued.	Frequencies.			
	1920	1921	1922	1923		1920	1921	1922	1923
25	1	2	1		85	93		2	9
30	1	6	1		90	86		1	11
35	1	9	3		95	54		1	14
40	2	14	4		100	10			9
45	5	24	6		105	6			7
50	6	52	7	1	110	5			3
55	14	61	11	1	115	2			1
60	21	39	18	1	120	1			1
65	48	31	21	2					
70	72	11	36	4	Total No.				
75	87	6	19	5	of strains	605	256	137	77
80	90	1	6	8	Mean weight				
					per plant	79	54	64	84

These are graphically portrayed in diagram C. The curves show that seasons 1920 and 1923 were good ones as evidenced by the high mean yields per plant. Seasons 1921 and 1922 were only fair, the former being the worst of the last four years. Giving due consideration to the vagaries of the seasons a gradual increase of the mean yield per plant is apparent. All those strains which showed an average weight per plant less than the mean weight per plant of all strains were eliminated in each season. The table below shows the annual average weights per plant of the best strains in each of the

chief varieties during the last five years, together with the average weight per plant of all the pure strains under trial and of padi grown from unselected seed,

Strain No.	1919	1920	1921	1922	1923	Average of 5 years.
Variety :—Seraup Kechil.						
36	95	108	80	71	117	94
52	93	113	74	70	115	93
48	85	102	69	85	120	92
68	87	111	68	77	111	91
20	86	113	73	64	109	89
257	88	119	67	82	87	89
371	87	101	73	75	107	89
146	86	103	76	79	96	88
6	85	95	71	76	107	87
8	79	97	65	79	104	85
151	83	98	68	76	99	85
517	80	95	67	69	98	82
Variety :—Radin—Best 6 Strains.						
7 Radin kuning	84	86	91	83	83	85
2 „ merah	72	81	92	86	75	81
13 „ puteh	81	79	91	69	80	80
1 „ merah	77	78	96	71	69	78
16 „ merah	75	79	85	74	75	78
4 „ merah	72	76	81	64	85	76
Variety :—Seraup Besar.						
15	82	106	76	58	101	85
509	75	93	58	82	93	81
3	76	97	64	54	98	78
590	70	97	74	61	82	77
Variety :—Padi Pahit.						
1	75	86	78	78	101	84
4	72	84	81	80	91	82
8	69	83	92	75	83	80
7	71	78	73	63	85	74
Average yield from unselected seed	49	51	45	43	49	47
Average yield per plant from all selected strains	66	79	54	64	84	69

The yields per plant in each season were derived by weighing the produce of 400 plants of each strain. These 400 plants were grown in four separate lines of 100 plants each every season, each line being planted in a different part of the experimental area. The yields produced by unselected seed were obtained by harvesting 400 plants in 10 straight lines of 40 plants each in an adjacent field planted by a Malay.

The following selections have been made for additional trials and multiplication in season 1923-24 for distribution in season 1924-25; Seraup kechil Nos. 36, 52, 48, 68, 1; Radin puteh No. 13; Radin kuning No. 7; Radin merah Nos. 2 and 4; Seraup besar No. 15 and Pahit No. 1. In anticipation of their heavy yielding capacities, each of the above selected strains has already been tested at the Titi Serong Experiment Station in half-acre plots during the past two seasons. They have also been tested in similar sized plots in various areas in the Peninsula.

Varying conditions throughout the country necessitated the trial of serveral strains in each rice growing district and though no attempt at the distribution of tested pure strains has yet been made, natural distribution has taken place in nearly all the areas where selected strains have been tested and the most suitable strain for many districts is already known.

Tests of pure strains in various areas can only, be carried out satisfactorily under control, because the cultivators prejudice in favour of the varieties which they have grown for many years and which they know will give them their normal crops, would lead them to use seed distributed broadcast for food or else to sow it on a small portion of the worst land in their possession, the best land being reserved for local varieties. Under these conditions the selected seed would probably produce smaller crops than the local variety and the cultivator would have proved to his own satisfaction the superiority of his own seed. Testing of pure strains has been most active in Perak North, thanks to the energy and euthusiasm of the Agricultural Inspector and his staff, (4) and it has been found that natural distribution of selected seed has taken place in the neighbourhood of many of the test areas. Thus, in the "mukim" of Kampong Lalang in the district of Kuala Kangsar, the Penghulu was given enough seed of the pure strain 'Seraup' No. 1 to plant a quarter of an acre of land in season 1921-22. "From his crop he distributed 35 "gantangs" of seed, (sufficient to plant 10 acres), to his friends who obtained the following yields which were carefully measured by an Agricultural Assistant."

Locality.	Strain.	Yield.	Locality	Strain.	Yield.
Kampong Lalang.	S.I.	380 gantangs.	Bendang Ulu Papan	S.I.	650 gantangs.
" "	"	690 "	Paya Panjang.	"	750 "
" "	"	720 "	Kampong Star.	"	650 "
" "	"	775 "	Bendang Pulai.	"	645 "
" "	"	740 "	" "	Local seed	575 "

1 gantang of padi weighs approximately 5.25 lbs.

The yields tabulated above show that the soils in which the padi was grown must have been very good rice soils, but nevertheless the yields from the selected seed being substantially higher than those from the unselected seed, natural redistribution is bound to take place in this "mukim." The example quoted is the best on record from the point of view of actual yields but is typical of the course of events in the neighbourhood of numerous test areas except that in most cases the redistribution has been much more extensive. Thus, in the neighbourhood of the Krian Experiment Station it is estimated that not less than 1,500 acres were planted with selected seed during the last padi season though no effort was made to advertise the seed. In a similar manner pure line Radin 13 has made good at Talang in the "mukim" of Saiong. Seraup Nos. 36 and 52 and Radin Nos. 7 and 2 have earned favour amongst the cultivators in Krian. At Lubok Merbau, Seraup 20 has established itself and Seraup 36 has proved itself in Bukit Gantang and Batu Kurau "mukims. The merits of Radin 2 are recognised in Larut Tengah and of Radin 7 in Province Wellesley. Radins Nos. 4 and 13 have spread considerably in Lower Perak and Radin Nos. 1 and 13 have proved good yielders in Malacca under adverse conditions. Good reports have been received of Radin 13 in Perlis and Tampin, and of Radin 2 in Alor Star and Radin 4 in Kota Bharu, and of other strains in various places.

A striking charateristic of nearly all the pure strains tested is the absence of empty grains on the ears. The fact that all selections were made by weight would probably account for this character as well as for the robust stand of the padi—another feature upon which comment has been made in several areas. Attention has been focused chiefly on two varieties, "Seraup" which has a maturation period of 7-8 months and "Radin" which normally matures in 6 months.

All 'wet' padi conditions in Malaya can be catered for by various strains of these two varieties of which populations comprising forty plants of each of the best twelve strains of each variety are compared in diagram D. The curves in this diagram are prepared from the following frequency tables.

Groups	No. of Plants		Groups contd.	No. of Plants.	
Grammes	Seraup	Radin		Seraup	Radin
7	1	6	112	70	50
22	7	12	127	41	30
37	22	45	142	16	14
52	45	66	157	2	2
67	78	72	Totals	480	480
82	103	91	Mean Weight per plant.	86	78
97	95	92			

The curves show that the eight months variety (Seraup) has a higher mean yielding capacity than the six months variety (Radin) or that there is a definite correlation between maturation period and yield in comparing these two varieties, though this correlation does not hold in comparing all varieties. The tillering curves (not represented) for the same populations are similar to the weight curves, the mean of the Seraup variety being 20.5 tillers as against 19.0 for the Radin variety. The chief features of Seraup Nos. 36 and 52 and Radin Nos. 7, and 13 are compared in the table below, the figures being the averages of numerous measurements.

	No. of grains per ear	Wt. per ear gramme	Length of ear cms.	Length of straw cms.	Length	Width	No. of tillers per plant.	Weight per plant.
Seraup 36	244	5.52	27.6	120	8 mms.	3.3mms.	21	94 gms.
,, 52	231	6.70	31.8	150	9 ,,	3.3 ,,	23	93 ,,
Radin 7	295	5.51	30.5	115	7 ,,	3.0 ,,	20	85 ,,
,, 13	236	5.40	27.8	120	7.9 ,,	3.0 ,,	20	80 ,,

It will be noticed that though S. 52 has heavier ears and more tillers per plant than S. 36, the latter is the better yielder under average agricultural conditions because of its robustness though the difference in yielding ability per acre is not more than twenty gantangs of padi. The Seraups are better than the Radins for milling purposes, the former averaging 63 per cent of rice (by weight) and the latter 60 per cent. Within each variety the various strains differ to a small extent in their milling qualities. It is quite impossible, on account of insufficiency of staff, to obtain any reliable information as to the extent to which Krian pure strains have already spread in the country or concerning the identity of the strains which have spread most in the various areas. In some areas strains are known to have been mixed somewhat though the composition of the mixture is on record in most cases, but this is unvoidable until large stocks of the best strains are available for general distribution in the districts to which they are most suitable. Multiplication of established strains is being arranged for the ensuing season so that stocks may be available for a scheme of general ditribution in season 1924-25 when an effort will be made to replace mixed strains by pure seed. Krian pure strains already form the bulk of the padi crop in several areas, though in most of these cases the strains have become somewhat mixed as in some of the "mukims" of Kuala Kangsar and Lower Perak, but it is hoped that this state of affairs will be remedied gradually when large stocks of pure seed become available. In conclusion, it may be expected that the use of selected pure strains will show increased average yields in various areas, the increases varying from five to twenty five per cent depending on local conditions and methods of cultivation.

1. Improvement of Cereals- -H. W. Jack —Malayan Agricultural Handbook 1922.

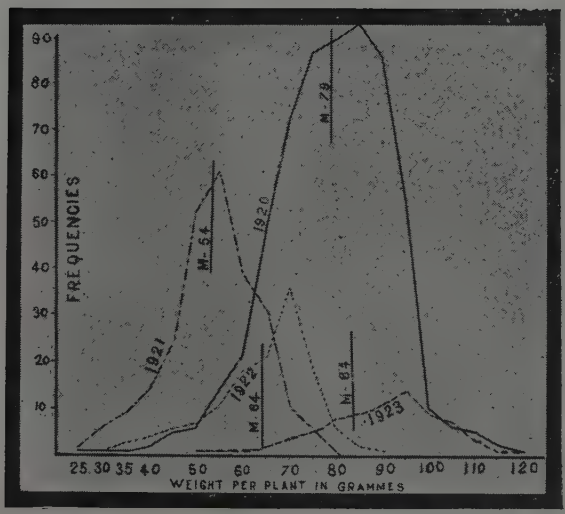

Diagram C :—Frequency curves of weight of all pure strains, 1920 to 1923.

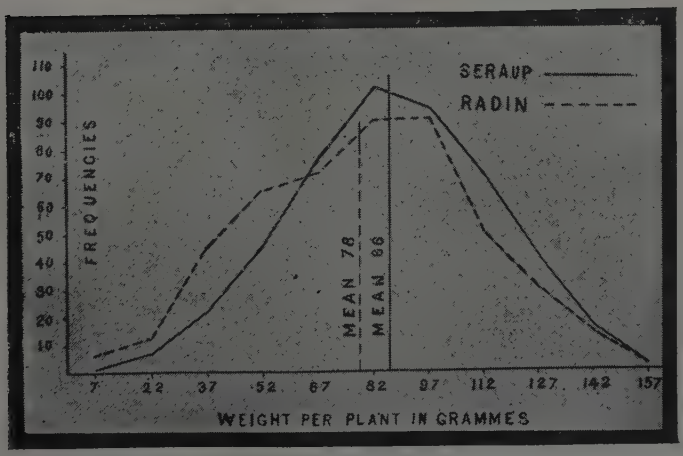

Diagram D :—Frequency curves of weight of populations of 480 plants of the Radin and Seraup varieties.

2. Species and Varieties, Their Origin by Mutation—Hugo de Vries 1906.

3. Plant Breeding in Scandinavia—L. H. Newman,—Canadian Seed Growers Association, Ottawa 1912.

4. Records of The Agricultural Inspector Perak North (unpublished.)

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FOOD PLANTS OF LEPTOCORISA, spp.

"PADI FLY." "RICE SAPPER." "PIANGGANG."

BY

G. H. CORBETT.

RECORDS and references concerning *Leptocorisa varicornis*, Fabr., *Leptocorisa acuta*, Thunb., or *Leptocorisa costalis*, Herr. Sch., in Malaya, relate for the most part to damage caused by both nymphs and adults to the grain of padi (*Oryza sativa*) when the seeds are in the milky stage, but information concerning alternative host plants is not given. An occasional remark that this insect feeds on grasses is found, but the species of grass is not mentioned.

Ridley (1), writing concerning *Leptocorisa acuta*, Thunb., states:—"What I take to be this insect is very common here in long grasses and I find it always on plants of *Panicum plicatum* grown in the Botanic Gardens."

Experiments conducted at Kuala Lumpur showed that *Leptocorisa* probably *costalis*, was capable of feeding and passing through its life cycle from egg to adult on the inflorescences of the following gramineous plants:—

Panicum colonum, Linn.,
Paspalum conjugatum, Berg.,
Paspalum platycaula, L.,
Andropogon sorghum, (L) Brot.,
Eleusine coracana, Gaertn.,
Pennisetum typhoideum, Rich.,
and *Panicum crus-galli*, L.

The time taken for this insect to develop from the hatching of the egg to the adult stage varied on *Panicum colonum* from 17 to 19 days; on *Paspalum conjugatum* 17 to 23 days; on *Paspalum platycaula* 18 to 19 days; on *Andropogon sorghum* 16 to 17 days, on *Eleusine coracana* 25 to 26 days; on *Pennisetum typhoideum* 19 days and on *Panicum crus-galli* 17 to 19 days.

Newly emerged nymphs on *Eleusine aegyptiaca* Desf., died in 6 to 8 days; on *Panicum indicum*, L., in from 2 to 3 days; on *Eleusine indica*, Gaertn., in 4 to 6 days; on *Panicum maximum*, Jacq., in 3 to 6 days; on *Eragrostis amabilis*, Wight., in 2 to 3 days; on *Centotheca lappacea*, Desv., in 2 days; on *Ischaemum ciliare*, Retz., in 2 to 3 days; on *Fimbristylis* sp. (a), in 2 to 3 days; on *Cyperaceae* (b), in 2 to 3 days, and on *Cyperaceae* (c) in 3 to 4 days.

Lefroy (2) in addition to *Andropogon sorghum*, *Pennisetum typhoideum* and *Eleusine coracana*, records *Panicum frumentaceum* and *Setaria italica* as suitable for *Leptocorisa varicornis*. Leopoldo

Uichanco (3), in addition to *Panicum crus-galli* and *Panicum colonum*, records *Panicum flavidum*, Retz., *Panicum reptans*, L., and *Digitaria consanguinea*, Gaudich., as suitable grasses for the development of *Leptocorisa acuta*, Thunb., but found that *Andropogon sorghum* did not seem to provide suitable food material for this insect. *Leptocorisa costalis* (?) in the experiments at Kuala Lumpur thrived on *Andropogon sorghum*, and newly emerged nymphs developed to adults on *Paspalum conjugatum*, but in the Philippines *Leptocorisa acuta* died in the 3rd instar on this grass.

Grasses and sedges on which the nymphs died in a few days might be found agreeable to *Leptocorisa costalis*. Austin (4) in fact, working with *Leptocorisa varicornis* found that *Ischaemum ciliare*, *Eragrostis amabilis* and two species of *Fimbristylis* served as food plants. The writer found that on *Ischaemum ciliare* newly emerged nymphs of *Leptocorisa costalis* died in 2 to 3 days; on *Eragrostis amabilis* in 2 to 3 days; on a species of *Fimbristylis* in 2 to 3 days, and on two other *Cyperaceae* in 2 to 4 days. Besides these and *Panicum crus-galli* and *Panicum colonum*, Austin further records as food plants *Cyperus polystachus*, Rottb., *Fuirena umbellata*, Rottb., *Paspalum scrobiculatum*, L., and *Cyperus rotundus*, L.

In passing it might be mentioned that Green (5) in Ceylon records *Leptocorisa acuta* on rubber, and Maki (6) in Formosa, mentions it as a pest of minor importance on mulberry.

Though insufficient work has been carried out to state definitely the species of grasses which are suitable for the development of *Leptocorisa*, spp., observations both here and elsewhere show that certain species of grasses around padi areas provide nutriment for the development of nymphs to adults, and the time taken for the insect to reach maturity on some of them compares very favourably with the time taken on the ripening grains of padi.

The practice of allowing grasses to flourish during the padi season, and volunteer padi and grasses to spring up between padi seasons, should not be encouraged, as ideal breeding places for this insect are thus maintained.

Finding varieties or strains of padi immune or resistant to the attacks of *Leptocorisa spp.* by breeding or selection would be a considerable undertaking, but there is no doubt that some varieties of padi are less susceptible than others. Leopoldo Uichanco (3) records "Binicol" as a variety of padi preferred by *Leptocorisa acuta* to others, and Jack, Economic Botanist of this Department, is of the opinion that the variety of padi known to the Malays as "Padi pahit" ("Pahit" has reference to the bitterness of the glumes and not to the grain), is hardly ever touched by this insect.

Bearded varieties of padi with thick glumes and closely set spikelets would probably be more resistant than non-bearded varieties with thin glumes, and possessing an attractive odour.

NOTE.—a.b. and c. These Cyperaceae have not at present been identified.

Literature Cited.

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2. 1905. Memoirs of the Department of Agriculture of India Vol. 2 No. 1.
"The Rice Bug. *Leptocorisa varicornis*, Fabr."

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Received for publication 14th May, 1923.

COVER CROPS AND THE SPREAD OF FOMES LIGNOSUS.

BY

F. Birkinshaw.

IN June 1922 advice was asked regarding *Fomes lignosus* attacks on an area of young rubber interplanted with *Centrosema plumieri* as a cover crop. It was stated that the cover crop appeared to assist the spread of the disease.

The area in question was burnt off in July 1919, cleared of timber, but not stumped, in the September following and planted towards the end of that year and early in 1920. The trees were contour planted. In September 1921 *Centrosema plumieri* was planted between the rows, the contour terraces on which the trees were planted being kept clean weeded. At the time of my visit the cover crop was growing luxuriantly and formed a very effective cover.

Fructifications of *Fomes lignosus* were found on several jungle stumps. In each of these cases the mycelium of the fungus was present in large quantities on the surrounding decaying vegetation formed by the cover crop as well as on the living stems of the crop. In no case seen was the cover crop killed by the fungus. It was clear that the fungus was spreading more rapidly than it would have done had the land been clean weeded.

It was decided to lay out an experiment to ascertain the possibility of controlling this disease by the determination of the number of jungle stumps infected and by isolating and treating each such infected area. Accordingly 500 jungle stumps were examined for fructifications of *Fomes lignosus*. Of these 22 were found showing the fructifications or a percentage of 4.4. These stumps were marked by means of red flags.

Three months later the same 500 stumps were again examined. On this occasion 24 fresh stumps were found developing *Fomes lignosus* fructifications, bringing the percentage of infection to over 9. In the majority of cases the fructifications on the 22 stumps originally marked had disappeared. It was clear therefore that no determination could be made at any one time of the number of infected jungle stumps by counting the number showing fructifications of the fungus. The idea of control on these lines was therefore abandoned and the complete stumping of the whole area recommended.

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THE TREATMENT OF A ROOT DESEASE OF BORNEO CAMPHOR

BY

F. W. South.

IN the Agricultural Bulletin of the Federated Malay States Vol. IX, No. 1. January, February and March, 1921 appeared an article entitled "An Important Root Disease of Borneo Camphor". This recorded the occurrence of attacks of the fungus *Rosellinia bunodes* (B. and Br.) Sacc. on the roots of trees of Borneo Camphor, "kapur" in Malay, (*Dryobalanops aromatica*, Gaertn.). These attacks occurred on small patches of land in the Kanching Forest Reserve, Selangor.

The treatment described in the article referred to above was carefully carried out during the first four months of 1921, the specimens of the disease having been sent to the Agricultural Department in the previous December. The work was done under the instructions of the Ag. Deputy Conservator of Forests, Selangor. On the conclusion of the work he submitted a report on the results obtained to the Director of Agriculture, from which he has kindly allowed the following information to be taken.

During the four months, January, February, March and April in which the work was in progress, a total of 393 trees were treated. The cost of the work was as follows:—

Wages	...	$274.75
Lime	...	17.50
Repairs to Tools	...	17.00
Total	...	$309.25

This gives an average of 79 cents per tree which is perhaps somewhat high. It must, however, be considered that the attacked trees had to be searched out over a very steep forest-clad hill and that lime had to be carried up to the infected patches, all without European supervision. As no further cases were found after the end of April, the results appear very creditable to the local staff of forest officers.

The "Sanitary squad" employed on this work was retained throughout May in order to search the whole Reserve for new attacks, or for any that might have been missed. None were found. The additional wages brought the total expenditure on the elimination of the disease to $357.75.

It was found that the attacks were fairly uniformly distributed in each compartment of the Forest Reserve and roughly corresponded in density to the density of the regeneration.

The main features of the treatment recommended were :—That the infected areas should be isolated by a trench 2 feet deep and 1 foot wide placed so as to include a margin of apparently uninfected soil 2 or 3 feet wide round each area.

That all the diseased plants inside the trench should be dug up and burnt, with as much as possible of the surface cover of leaves and twigs.

That each patch should be well limed, at the rate of 2 tons per acre, and should be well forked over, all bits of wood in the soil being removed and burnt.

In practice it was found that a much smaller area needed to be trenched than was expected, in fact that 3 feet radius from the attack was sufficient. It was also found that the virulence of the pest was perhaps over-rated, or the efficiency of lime under-rated, because in many cases seedlings growing inside a trench continued to be quite healthy.

No further attacks have been reported to the Agricultural Department since this treatment was undertaken.

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JELUTONG.

BY

B. J. EATON & J. H. DENNETT.

SINCE there do not appear to be many recorded analyses of jelutong in the literature on rubber etc. the following results of analyses of samples examined recently in our laboratories are placed on record. The results must be regarded as incomplete, since they show only rubber, resin, moisture and ash, while the rubber content is determined by difference, and the "resin" represents the acetone extract. It is possible that jelutong contains nitrogenous substances, like the rubber from Hevea and other latices, but no determination of the nitrogen content has been made.

Description of Samples :—The following samples were received and investigated :—

(1) Jelutong latex.
(2) Crude jelutong prepared by Chinese.
(3) Crude jelutong prepared by native methods.
(4) So called purified jelutong.

(1) *Jelutong Latex :*—This consists of a white emulsion similar in appearance to Hevea latex. It can be coagulated with acetic acid or alum and also anaerobically by placing it in sealed vessels. Anaerobic coagulation yields a coagulum which has no unpleasant odour even after standing for several days and this indicates that the amount of organic nitrogenous matter present must be very small.

The crude coagulum prepared from this latex contained 75.5 per cent of moisture and the dry coagulum contained 79.3 per cent of "resin." The total solids in 100 ccs. of the latex (78.4 grams.) amounted to 18.2 per cent and contained 79 per cent of "resin."

The weight of the dry coagulum from 100 ccs. of latex was 17.6 grammes, equivalent to 22.5 per cent by weight.

(2) *Chinese Jelutong :*—This consisted of a compact coagulum.

(3) *Native Prepared Jelutong :*—This sample had a honeycomb structure and was sticky and discoloured.

(4) *"Purified" Jelutong :*—This sample was of a greyish white colour and gummy in character.

Results of Analyses :—The results of analyses are summarised in the table attached.

Remarks and Conclusions :—The results obtained do not indicate any marked difference between the samples of jelutong prepared by different methods, except in respect of the moisture content, which

probably depends largely on the freshness of the material. The moisture content of the Chinese sample is high.

The "resin" content varies from 75.9 to 80.9 per cent on the dry product and the "rubber" content from 19.1 to 24.1 per cent, depending on the "resin" content.

The ash in all the samples is low which indicates that none of the samples have been adulterated by the addition of inorganic or mineral substances.

The so-called purified jelutong has the lowest "resin" content and highest rubber content, which may be due to removal of acetone soluble substances during purification.

The results confirm previous available analyses.

Notes:—The following extract from a translation of "De Nuttige Planten van Nederlansch-Indie" by K. Heyne published in 1917 are of interest in connection with this product.

"The jelutongs are scattered trees growing to enormous sizes and are among the tallest of jungle trees. The largest specimen seen by Van Romburgh had a circumference of 24½ feet and a height estimated at 150 feet. Wechel (Teysmannia 1911, p. 153) gives the diameter as 3 to 6.5 feet and height of trunk to first branches as 100—165 feet. The trunk is usually very straight and the crown close.

In Borneo the Dyaks distinguish three varieties, the white and black, growing in swamp lands and the red growing in the hills. The last named however is stated to yield very little latex. The white and black varieties refer to shades of bark.

Ridley (Straits Bulletin 1903, p. 96) describes the wood as soft, white and not durable. It is used for making boxes, planks, models, Chinese shoes and recently for the manufacture of match sticks.

The tree belongs to the genus Dyera and there are probably several species. In Malaya, *D. Costulata* and *D. Laxiflora*, the former having a reddish bark when cut and the latter a whitish bark. The former is said to contain much more juice than the latter. Both species grow scattered in the valleys and on the hills in Malaya to a height of 500 feet or more, but seldom in swampy land.

Tapping:—Te Wechel (l.c.) describes the method of tapping in Borneo as follows:—Four, five or six cuts are made round the tree, as broad as a hand, right to the wood, and 4½ feet above the ground. On returning about the eighth day the wounds are enlarged, to the breadth of about 3 fingers, with a parang. The enlarging of the wounds to the right and left is stopped when the wounds almost touch each other. The tapping is continued downwards to the ground and higher up the tree as far as the parang will reach.

The first exudation of watery liquid is discarded, but that which appears after about five minutes coagulates on the tree to a thick milk.

The above method of tapping results in the death or destruction of the trees. Trees were exploited later in Malaya, Sarawak and Borneo under European control, chiefly by the company known as the United Malaysian Coy. and two subsidiary companies, all since defunct.

The method of tapping employed was to cut a long V with a channel from the base of the V leading to the collecting cup. The production of latex and the recovery of the trees was said to be good. Trees were however killed by tapping, owing to the difficulty of supervising the native tappers. No systematic tapping is however being carried out at present, although at least one European is collecting jelutong in Pahang and Kelantan.

Preparation:—After tapping and collection, the collector adds about one-third water to the milky juice collected to prevent fermentation and coagulation. The latex is then poured into a basin, diluted with three parts of water and 1/8 bottle of paraffin and a little ground "obat pantung" (Note:—In the Straits Bulletin 1903, 191, a recipe for the preparation of jelutong is given, in which paraffin and "plaster" are used as coagulants, also alum.)

The mixture is stirred for about 2 hours and then left till the following morning, by which time coagulation has taken place and the water not absorbed by the coagulum is poured off.

The coagulated jelutong is treated repeatedly with hot water and then rolled with a bottle. A block weighing 23—30 katies is prepared and kept in a stream. Te Wechel considers that the jelutong thus obtained weighs about three times the weight of the juice collected, due to absorption of water. A large tree is said to yield ½ picul of juice and trees of medium size can be tapped for about a year.

Market Products & Uses:—The name jelutong has superseded the old names "Dead Borneo" or "Pontianak." The product consists of caoutchouc, resin and water. Material from Palembang, free from water and dirt, was found to contain 21.3 per cent of caoutchouc and 78.5 per cent of resin while a sample from Pontianak yielded 22 per cent of caoutchouc and 78 per cent of resin. The former crude sample contained 18.9 per cent of water and the latter 27.2 per cent of water. The difference in value of samples of jelutong of different origins are probably due chiefly to varying percentages of water. The product usually appears on the market in blocks, having the consistency of putty and containing water. The exterior of the block is usually greyish while, white the inside is white. The product has a peculiar acrid odour.

Palembang jelutong is said to contain most caoutchouc (15—18 per cent) followed by Bandjermasin (12—14 per cent) and finally by that from Pontianak.

Our figures show the samples examined to be of high quality in respect of caoutchouc content.

Jelutong, which is not kept under water, is said to deteriorate quickly.

It will be remembered that during the early days of the rubber industry when raw plantation rubber was fetching a high price, the United Malaysian Coy. erected extensive factories for the extraction of the resin from jelutong and marketed a product containing over 90 per cent of caoutchouc.

Little information is avaliable as to the commercial uses. It is probably used to some extent in rubber manufactories for shoes and other articles and is also stated to be used in asbestos, celluloid and linoleum factories. According to Ridley (Straits Bulletin 1903, page 95) it is used largely to make architectural work water tight.

TABLE.

	Jelutong latex.	Fresh Jelutong from latex.	Chinese Jelutong.		Native Jelutong.		Purified Jelutong.	
			Fresh Sample.	Dry Sample.	Fresh Sample.	Dry. Sample.	Fresh Sample.	Dry. Sample.
Total Solids (%)	18.2	24.5	52.9	...	82.3	...	82.1	...
Moisture (%)	...	75.5	47.1	...	17.7	...	17.9	...
Ash (%)	...	...	0.05	...	trace	...	0.36	....
Resin (%)	...	79.0*	42.2	80.5	67.3	80.9	62.3	75.9
Rubber (%) by difference.	...	21.0*	10.7	19.5	15.0	19.1	19.4	24.1

* These figures represent "resin" ex-rubber content calculated on the dry coagulum.

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ROSELLE SEED OIL.

BY

C. D. V. GEORGI.

AN investigation has recently been carried out to determine both the oil content of Roselle seed—*Hibiscus Sabdariffa* var. *Altissima*—and the characteristics of the oil.

Although it is extremely unlikely that surplus supplies of this seed will ever be available for oil expression, seeing that this plant is cultivated primarily for its fibre and for this purpose is cut down before the seed forms, it was considered advisable to have the figures for the purposes of record.

The seed was obtained from Mr. E. Mathieu, Superintendent Government Plantation, Kuala Kangsar, who made the original suggestion.

OIL CONTENT.

The results of the analysis of the sample of seed were as follows:—

	per cent.
Moisture	12.9
Oil (Chloroform extract)	16.8
Residue (by difference)	70.3
Nitrogen	3.29
Oil (calculated on dry seed)	12.3
Nitrogen (calculated on dry oil-free residue) ...	4.68

CHARACTERISTICS OF OIL.

The results of the determination of the constants of the oil, which was expressed from seed in a small laboratory hand-press, were as follows. The figures for Kapok seed oil and Cotton seed oil are added for purposes of comparison.

The oil, when freshly expressed, was clear, brownish yellow in colour, with a sweetish sickly smell. There was a slight deposit of white sediment on standing.

OIL	Roselle Seed Oil.	Kapok Seed Oil.	Cotton Seed Oil.
Density at 15.5°C. ...	0.923	0.918	0.923
Refractive Index at 20°C. ...	1.4715	1.4710	
Saponification value ...	193.1	191.0	193.0
Iodine value (Wijs) ...	107.3	94.3	110.0
Acidity (Oleic Acid per cent)	2.2		
Unsaponifiable (per cent) ...	1.1	0.8	0.9
FATTY ACIDS.			
Solidifying Point (Titer value) ...	28°C	28.4°C	35°C
Mean Molecular Weight ...	282.4	284.3	

Results of Experiments.

These experiments show that this variety of Roselle seed contains about 17 per cent of an oil, which is very similar to both Kapok seed and Cotton seed oils and could doubtless be used for the same purposes as these oils.

The residue remaining after the expression of the oil is rich in albuminoids, the nitrogen content of the dry residue being about 4.7 per cent., corresponding to about 29 per cent of albuminoids.

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SODIUM SILICATE IN SOAP MANUFACTURE.

IN connection with investigations of locally manufactured soaps which are being carried out in the Chemical Division of the Department of Agriculture, it has been ascertained that sodium silicate is being used by at least one local firm.

The following information on the use of this substance, abstracted from "The Chemical Trade Journal and Chemical Engineer" (Vol. LXII No. 1872 of the 6th April 1923) is therefore of interest.

Within recent years the practice of incorporating varying amounts of sodium silicate in common household soaps has become widely diffused, more especially in the United States.

The use of the silicate make possible the production of an attractive bar of soap and contributes to the general lowering of prices, not only on account of the reduction of the true fatty acid content of the soap, but also because the manufacturer can utilise oils which melt at low temperatures and yet obtain soaps containing large quantities of the valuable sodium oleate which will not dissolve too readily when subjected to the conditions of the household washboard.

As in the case of sodium carbonate and other alkalis, sodium silicate has a positive detergent action when used in soap and its function is not merely that of a filler or adulterant. The fact that soaps containing silicate do not "bloom" would not in itself be sufficient to justify the higher price paid by the soap maker for this substance, but in practice it has been found to have a greater value than sodium carbonate.

Although much information on this point has not been available hitherto, researches conducted recently by two large Americans firms (Vide Industrial and Engineering Chemistry March 1923) fully justify on scientific grounds the predilection of soap makers in favour of sodium silicate. Prior to 1903 almost all theories of the detergent action of soaps were based on the belief that the alkali formed by the hydrolysis of the soap was the active agent in washing.

Since that date, due to researches chiefly by Donnan in England and Hillyer in America, it has been recognised, that although factors such as wetting, lubrication, deflocculation, solution and lathering contribute to detergent action, the power of effecting emulsification in the dominant factor.

It has now been found by American workers that sodium silicate improves the emulsifying power of a true soap to a far greater extent than sodium carbonate. This is particularly true when the silicate possesses a high ratio of silica to soda.

If the concentration of the silicate be not over 20 per cent., the suds formed are also stabilised. The effect of hard waters on soaps containing sodium silicate has also been investigated and it has been found that lime or magnesium compounds in such waters may be precipitated either as fatty acid salts, or silicates.

The conditions governing the proportions formed are complex but it has been estalished that at 100°C the water softening action of the silicate is very pronounced and results in a distinct saving of the true soap.

It does not appear probable that the silicate possesses any marked detergent properties, but that the increased emulsifying powers conferred on the soap produce the apparant detergent action.

The work has shown that silicated soaps have a quite legitimate place in household laundry work.

B. J. E.

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MARKET PRICE LIST 2nd QUARTER 1923.

	London.		New York (In dollars gold.)	
Oil Seeds.				
Castor	£22	per ton		
Coconut, desiccated	£43.10-£45.5	,,		
Copra	£30	,,		
Cotton	£10-£11	,,		
Gingelly	£24-£25	,,		
Groundnuts, undecorticated	£17-£18	,,		
Groundnuts, decorticated	£23-£24	,,		
Linseed	£22	,,		
Palm kernels	£20	,,		
Oils.				
Castor	£53-£54	per ton	14½-16 cts.	per lb.
Coconut	£48-£50	,,	9-11¼ ,,	,,
Cotton seed	£41-£45	,,	10½ ,,	,,
Croton			$1.00-1.10	per lb.
Gingelly			96 cts.	per gallon
Groundnut	£45	,,	15½ cts.	per lb.
Linseed	£50	,,	$1.17	per gallon
Palm	£39-£42	,,	9 cts.	per lb.
Palm kernel	£45	,,	9½ cts.	,,
Oil Cakes.				
Coconut	£7.15-£8.5	per ton		
Groundnut, semi decorticated	£10.10	,,		
Groundnut, undecorticated	£8.10	,,		
Linseed	£10.15	,,		
Palm kernel	£5	,,		
Essential Oils.				
Cajeput	3/10-3/11	per lb.	80 -85 cts.	per lb.
Camphor, crude	3/-	,,	72 -73 ,,	,,
Camphor, refined	3/6	,,	90 -92 ,,	,,
Camphor, oil	82/6	per cwt.	11½-15 ,,	,,
Cananga	9/-	per lb.	$2.25-2.50	per lb.
Cinnamon, bark	3/-	per oz.	$12-15	,,
Cinnamon, leaf	4d	,,	$2.00	,,
Citronella, Ceylon	3/2	per lb.	70-74 cts.	per lb.

	London.		New York (In dollars gold.)	
Citronella, Java	4/- 4/3	per lb.	85-87½ cts.	per lb.
Clove	7/- 7/3	,,	$1.75-1.95	,,
Ginger	23/-	,,	$5.75-6.00	,,
Lemon grass	2¾d	per oz.	80-85 cts.	,,
Lime, expressed	7/-	per lb.	$1.70-1.80	,,
Lime, distilled	3/3 - 3/6	,,	60-65 cts.	,,
Nutmeg	4/6	,,	90 ,,	,,
Patchouli, leaves	-		22-25 ,,	,,
Patchouli, Penang	29/- 30/-	,,	$8-8.50	,,
Vetiver, Bourbon	20/-	,,	$5.50-6.00	,,
Ylang Ylang, Manila	-		$30.00-40.00	,,
Spices.				
Capsicums	40/- - 70/-	per cwt.	14½-17 cts.	,,
Chillies	100/- - 150/-	,,	27-30 ,,	,,
Cinnamon	7½d - 10½d	per lb.	20-22 ,,	,,
Cloves, Zanzibar	1/-	,,	26-27 ,,	,,
Cloves, Penang	3/-	,,		
Ginger, Jamaica	190/- - 230/-	per cwt.	37-44 ,,	,,
Ginger, Japanese, Cochin	60/- - 65/-	,,	15½-16 ,,	,,
Mace	1/5 - 1/8	per lb.	38-47 ,,	,,
Nutmegs, 110's	10½d	,,	24-25 ,,	,,
Nutmegs, 80's	1/1½	,,	26-27 ,,	,,
Pepper, black	4¼d	per lb.	11-11½ ,,	,,
,, white	6½d	,,	14-14½ ,,	,,
Turmeric	40/- 50/-	per cwt.	7-9½ ,,	,,
Drugs.				
Areca Nut	37/6	,,	9 ,,	,,
Coca, leaves	-		40-45 ,,	,,
Cocaine, hydrochloride	14/9	per oz.	$7.07-7.50	per oz.
Ipecacuanha	6/9 - 7/-	per lb.	$1.80-2.00	per lb.
Papain	-		$2.15-2.25	per lb.
Quinine sulphate	2/3	per oz.	50 cts.	per oz.
Natural Dyestuffs and Extracts.				
Annatto, fine	-		26-29 cts.	per lb.
,, seed	8d	per lb.	6-7 ,,	,,
Cutch, Borneo, solid	28/6 - 29/6	per cwt.	4¾-5½ ,,	,,
Gambier, block	47/6	per cwt.		
,, cubes	62/6 - 65/-	,,		
Gums.				
Damar	30/- - 150/-	,,	32-34 cts.	per lb.
Dragon's blood, reeds	£18-£20	,,		

	London.		New York (In dollars gold.)
Dragon's blood, lump -	£11-£28	cwt.	
Fibres.			
Cotton, American -	15½d	per lb.	
Cotton, Egyptian, Sakellaridis -	17d	„	
Hemp, African sisal -	£36	per ton	
„ Manila -	£33.10	„	
„ New Zeland -	£32.10		
Kapok, Java -	1/2 - 1/7	per lb.	
„ Indian -	10d - 1/-	„	
Foodstuffs.			
Cocoa, Ceylon, plantation -	78/-	per cwt.	
Coffee, East India "B" size -	85/- - 100/-	„	
Sago, pearl -	24/- - 30/-	„	
„ flour -	16/- - 17/-	„	4½-5 cts. per lb.
Sugar, West Indian crystal -	58/6 - 60/-	„	
Tapioca, flake -	3¼d - 4½d	per lb.	
„ flour -	18/- - 22/-	per cwt.	4¼-7 „ „
Miscellaneous Chemicals.			
Acetic, acid glacial -	£70	per ton	$12-12.30 per 100 lbs.
„ „ 80% comml	£47	„	$9-9.30 per 100 lbs.
Acetone -	£125	„	22½ cts. per lb.
Ammonia -	£32-£34 (.880)	„	7-7½ cts. per lb. (26°.)
Calcium acetate -	£19-20	„	$3.50 per 100 lbs.
Citric acid -	1/8½d	per lb.	49-54 cts. per lb.
Creosote -			50-55 „ „
Cresote oil -	10½d	per gallon	20-22 cts. per gallon
Formalin -	£87	per ton	15-15½ cts. per lb.
Lime juice, raw, clarified -	2/6-2/9	per gallon	50-60cts. per gallon
Lime juice, concentrated -	£22	per basis[1]	
Sodium bisulphite -	£21-£23	per ton	
Sodium sulphite, anhydrous -	£28	„	
Wood alcohol, 97% -			$1.12-1.17 per gallon

N.B.—1 American Gallon = .833 Imperial Gallon.

[1] Basis = 108 gallons, 64 ozs. Citric Acid per gallon.

NOTE.

Suckers of Sisal hemp (*Agave rigida var. sisalana*) can now be supplied in large quantities. Price $2/- per 100. Application for same should be addressed to the Agriculturist, S.S. and F.M.S.

ERRATA.

Vol. XI, No. 5, p. 105 line 2 *for* 5 acres *read* ·5 acres
107 line 7 *for* unusually grown in localities there *read* usually grown in localities where.

Vol. XI, No. 6, p. 144 Table VII Total average yield per annum *for* 13,991,280 *read* 149,860,280.